AGE- AND CAUSE-SPECIFIC MORTALITY PATTERNS AND TRENDS IN AN URBAN INFORMAL SETTLEMENT, KIBERA, KENYA, 2009–2018

CLIFFORD ODUOR OTIENO

MASTER OF SCIENCE

(MEDICAL STATISTICS)

UNIVERSITY OF NAIROBI

2020

Age- and Cause-specific mortality patterns and trends in an urban informal settlement, Kibera, Kenya, 2009–2018

Clifford Oduor Otieno

W62/11221/2018

A thesis submitted in partial fulfilment of the requirements for the award of a Master of Science degree in Medical Statistics of the University of Nairobi

2020

DECLARATION

This thesis is my original work and has not been presented in any institution leading to the award of a degree or any other award.

Signature……Date……..……...

Clifford Oduor Otieno

W62/11221/2018

SUPERVISORS APPROVAL

I confirm that this thesis was written by the above-named student and has been approved for submission in partial fulfilment of the requirements for the award of a Master of Science degree in Medical Statistics of the University of Nairobi.

Signature ……Date……20th November 2020……

Dr. Peter Nguhiu

Lecturer,

University of Nairobi Institute of Tropical and Infectious diseases (UNITID)

Signature…… ……. Date…16th November 2020……

Dr. George O. Agogo

Statistician

Centres for disease control and prevention (CDC)-Kenya

DEDICATION

I dedicate this work to my beloved family, my loving wife Maureen, my son Cassidy and my parents who are always a source of moral support, motivation and encouragement. Their love, concern, support and enthusiasm are an inspiration.

ACKNOWLEDGEMENT

First and foremost, I wish to thank the Almighty God Jehovah for seeing me through this project. The Lord God almighty is indeed gracious, slow to anger, abounding in love and faithful. Special gratitude goes to my supervisors Dr. Peter Nguhiu and Dr. George Agogo for their guidance. I am equally grateful to my mentors Drs. Godfrey Bigogo, Patrick Munywoki and Jennifer Verani for their encouragement and patience in reading, correcting and refining this work. Thanks a lot for every single minute you spared to read and give guidance.

I appreciate the role played by all the UNITID lecturers, many of whom are my mentors, for giving me a firm foundation in medical statistics.

I also appreciate my colleagues both at work and school who stood by me throughout the course. I must say that their contributions were overwhelming and may God bless them all.

Finally, I wish to thank the residents of Kibera informal settlement who voluntarily agreed to take part in the study all for the greater aim of improving global health.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

- AIDS Acquired immuno-Deficiency Syndrome
- CDC Centres for Disease Control and Prevention
- CD Communicable Diseases
- CoD Cause of Death
- CRVS Civil Registration and Vital Statistics
- CSMF Cause Specific Mortality Fractions
- GBD Global Burden of Disease
- HDSS Health and Demographic Surveillance System
- HIV Human immunodeficiency Virus
- InterVA Interpretation of Verbal Autopsy
- KEMRI Kenya Medical Research Institute
- LMIC Low- and middle-income countries
- NCD Non-Communicable Diseases
- PBIDS Population-Based Infectious Disease Surveillance
- PYO Person-Years of Observation
- SDG Sustainable Development Goal
- SSA Sub-Saharan Africa
- VA Verbal Autopsy
- UNICEF United Nations International Children's Emergency Fund
- WHO World Health Organization

ABSTRACT

Title: Age and cause specific mortality patterns and trends in an urban informal settlement, Kibera, Kenya, 2009–2018

Background: Effective health services planning and prioritization require reliable and timely mortality data. In addition, data on deaths and causes of death is needed for evaluating the impact of public health interventions. However, these data are lacking for populations in resource-poor settings particularly for those living in urban informal settlements. Kibera slum being the largest urban informal settlements in Kenya is characterized by overcrowding, poor infrastructure and poor sanitation. However, compared to rural settings data on mortality in children and adults residing in informal settlements is lacking.

Broad Objective: To determine patterns and trends in age and cause specific mortality rates within an informal settlement in Kibera, Kenya.

Specific Objectives: The specific objectives were to determine the age-and cause specific mortality rate and the trend in Age and cause specific mortality rate in an urban informal settlement in Kibera, Kenya.

Study Design: This was a retrospective open cohort study of all deaths among residents followed within the KEMRI and CDC population-based infectious disease surveillance (KEMRI Protocol #2761).

Methodology: Secondary data was extracted from the KEMRI and CDC population-based infectious disease surveillance database for all deaths occurring among residents of all ages at the time of death, between 1st January 2009 and 31st December 2018. Person years of observation

was computed annually for the period for all individuals who were residents of the study area. A Bayesian probabilistic model (InterVA model) was used for assigning causes of death (CoD) using collected data from verbal autopsy interview data. Cause specific mortality fractions and rates were computed using the generated CoDs. Age-and cause mortality rates were computed as deaths per 1000 person-years of observation. We stratified mortality analysis by sex and age groups. Trends in age-and cause specific mortality rates over time were identified using a non-parametric test; Mann-Kendall trend test.

Results:

The overall mortality rate was 4.4 per 1,000 person years of observation (pyo) (95% Confidence Interval, CI; 4.2 –4.7) (Females: 3.6 (95% CI 3.3–4.0); Males; 5.2(95% CI 4.8–5.7)). Among children under 5 years the mortality rate was 10.9 per 1,000 pyo(95% CI ;9.9–12.0) while Among persons 5 years and above the mortality rate was 3.3 per 1,000 pyo(95% CI ;3.1–3.5).The highest mortality rate was observed in children under 1 year (41.5 per 1,000 pyo; 95% CI 36.6–46.9) and persons aged 65years and above (32.6 per 1,000 pyo; 95% CI 21.5–47.5) and lowest in persons aged 5-14years (1.1 per 1,000 pyo; 95% CI 0.9–1.4). Overall, most deaths were attributed to acute respiratory infections including pneumonia (18.1%) followed by HIV/AIDS related deaths (12.8%), Pulmonary tuberculosis (6.9%) and then malaria (5.9%).Among children under 5 years the leading cause of death (CoD)with the highest cause specific mortality rate (CSMR) was acute respiratory infection including pneumonia (3.84 per 1,000 pyo) while among persons 5 years and above the leading CoD was HIV/AIDS related deaths (0.61 per 1,000 pyo). Overall, mortality rate significantly declined (Kendall τ=-0.87, $p<0.001$) over time from 6.7 per 1,000 pyo (95% CI 5.7–7.8) in 2009 to 2.7 per 1,000 pyo (95%

CI 2.0–3.4) in 2018. This decline in mortality rates was observed by sex and age-group. Despite this decline in mortality rates, males had consistently higher mortality rates overtime than females except in 2011. During the study period, acute respiratory infection including pneumonia deaths remained the leading CoD among children under 5 years. However, there was a significant decline in CSMR (Kendall τ=-0.73, p=0.004) from 5.06 per 1,000 pyo in 2009 to 0.61 per 1,000 pyo in 2018. HIV/AIDS related deaths remained the leading CoD among persons 5 years and above. However, there was a decline from 1.07 per 1,000 pyo in 2009 to 0.31 per 1,000 pyo in 2018 though this was not statistically significant (Kendall τ=-0.33, p=0.21). On the other hand, causes of death due to pulmonary tuberculosis among persons 5 years and above significantly declined (Kendall τ=-0.60, p=0.02). Overall, there was a significant decline in mortality due to communicable diseases among children under 5 years (Kendall τ=-0.73, p=0.004).

Conclusion:

Overall age specific mortality rates declined over time. Despite declines in several important infectious causes of death, communicable diseases have remained to be the leading causes of death in this community. In addition, injuries and other NCDs are a major cause of adult mortality. High disease burden in informal settlements may threaten progress towards Sustainable Development Goals.

CHAPTER ONE: INTRODUCTION

1.0 Background information

Accurate and timely mortality data is important for health services planning and prioritization, [1]. Data on levels and trends in mortality highlight new and ignored health problems[2,3].The Sustainable Development Goals (SDGs) global agenda further highlights the importance of mortality data by not only including indicators expressly focused on all-cause mortality but also death registration and cause specific mortality[4]. However, there is scarcity of reliable mortality data particularly among countries with limited resources and greatest health needs[5,6]. Globally in 2015, 41.2% of deaths were not registered and Sub-Saharan Africa(SSA) had the fewest number of deaths being registered.[7].

The most effective way of estimating age-specific mortality is through an efficient and effective civil registration system[7]. However, in poor resource settings such vital event surveillance systems are weak or non-existent[8,9]. Birth and death registration in Kenya was introduced in 1904.[10]. However, an assessment of the Civil registration system determined that the system was not effective in providing reliable vital statistics data [11].In 2017, the national death registration coverage was at 41.2% with some counties recording as low as 4.1%[10].

In addition to the Civil registration system, health facilities are expected to play a major role in generating mortality data. However, resource poor-settings lack quality and reliable hospital mortality reporting[12]. The situation is exacerbated by the fact that health care utilization is relatively low in most developing countries[13]. Consequently, deaths occurring outside health facilities are not properly documented.[14].

Chances of a death being registered and documented depends on socioeconomic status of the community and nation in which the death occurs[15]. Globally, millions of poor people including those living in informal settlements miss from national statistics[16].In cities such as Mumbai, India, and Nairobi, Kenya, more than 50% of the population live in slums[17]. These settlements are characterized by overcrowding and poor sanitation with potential adverse health impact [18]. In addition, access to health care within the settlements is often very limited[19]. However, relatively limited data is available on mortality in children and adults.[20].

Population-based surveillance systems are convenient platforms for understanding the level of mortality within a population in situations where there is absence of strong vital registration systems [21–23]. Currently, available mortality estimates are based on surveys which may not be accurate[16,24]. In population-based surveillance Verbal autopsy(VA) has been advanced for assessing cause specific mortality[25].

Since 2006 ,the Kenya Medical Research Institute (KEMRI) in collaboration with the US Centers for Disease Control and Prevention (CDC) have conducted such a population-based infectious disease surveillance (PBIDS) in the Kibera informal settlement situated in Nairobi, Kenya[26]. The active population under surveillance is approximately 22,000 in a study area of 0.37 km^2. Field workers visit households regularly after every 6 months to administer standardized questionnaire to each household member as well as record demographic events such as births, deaths, in- and out-migrations in the household. The aim of this surveillance platform is to track causes and burden of common infectious diseases over time in both urban and rural settings. In addition, the platform is used to evaluate public health impact of existing and new

health interventions. As part of this evaluation, deaths among all consented participants are registered and Verbal autopsies conducted to ascertain causes of death.

Our study was aimed at bridging the information gap in mortality patterns and trends in an informal settlement in Kibera, Kenya. In addition, provide information on the leading causes of death using data from an on-going population-based surveillance platform.

1.1 Problem statement

There is a lack of reliable mortality data in African and Asian regions mainly due to weak or lack of vital registration systems and low health care utilization[27,28]. Kibera slum being the largest urban informal settlements in Kenya is characterized by overcrowding and poor sanitation with potentially unfavourable health outcomes. However, relatively limited data is available on child and adults mortality in these settlements[12]. Mortality data from population-based surveillance in Kibera provides a means of filling this information gap.

1.2 Justification

Kenya like most low- and middle-income countries (LMICs) need reliable mortality data for health services planning, prioritization, monitoring and evaluation. Such health statistics are vital in monitoring progress towards the health-related sustainable development goal (SDG), particularly the 3rd goal. Informal settlements are characterized by poor health outcomes yet there is limited mortality information. Therefore, the provision of reliable information on mortality can help the government and other stakeholders in planning and prioritization of health interventions in this community.

1.3 Research questions

1. What is the age specific mortality rates in an informal settlement in Kibera, Kenya?
2. What is the cause specific mortality rates in an informal settlement in Kibera, Kenya?
3. What is the trend in age specific mortality rates in an informal settlement in Kibera, Kenya?
4. What is the trend in cause specific mortality rates in an informal settlement in Kibera, Kenya?

1.4 Objectives of the study

1.4.1 General objectives

To determine patterns and trends in Age and cause specific mortality rates among a defined population within an informal settlement in Kibera, Kenya.

1.4.2 Specific objectives

1. To determine the age specific mortality rates in an informal settlement in Kibera, Kenya
2. To determine the cause specific mortality rates in an informal settlement in Kibera, Kenya
3. To determine the trend in age specific mortality rates in an informal settlement in Kibera, Kenya
4. To determine the trend in cause specific mortality rates in an informal settlement in Kibera, Kenya

1.5 Significance

Mortality data provide important information needed for policy making, planning, and evaluation of health interventions. Informal settlements are characterized by poor health outcomes yet there is limited information on mortality in children and adults living in these informal settlements. The study aims at providing mortality patterns and trends among a defined population in an informal settlement Nairobi, Kenya.

CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

This chapter reviews literature that has been published across the globe on patterns and trends of age-and cause specific mortality. The review is organized based on the specific objectives of the study.

2.1 Age-specific mortality patterns and trends

2.1.1 Children under-five years mortality

Child death rates globally have decreased significantly between the years 2000 and 2017[29]. The United Nations Inter-Agency Group for Child Mortality Estimation (UN-IGME) estimated that globally, the under-five mortality rate reduced to 39 from 93 deaths per 1,000 live births between 1990 to 2018.Under five mortality rate remained relatively high in Sub-Saharan Africa (SSA) at a rate of 78 deaths per 1,000 live births. In addition, the report estimated that the global mortality rate among neonates and infants was 18 and 29 deaths per 1,000 live births respectively infants.

In 2014, the Kenya demographic and health survey (KDHS) estimated a mortality rate of 52 deaths per 1,000 live births among children aged below 5-years. Neonates and infants had a mortality rate of 22 and 39 deaths per 1000 live births respectively. A decline was observed in 2018 with estimated under 5 mortality rate at 41 deaths per 1,000 live births. Neonatal and infant mortality rate was 20 and 31deaths per 1,000 live births respectively[30].In 2016,WHO global heath observatory reported mortality rates among infants below 1 year to be 41 deaths per 1,000 person years of observation in males and 34 deaths per 1,000 person years of observation in

females in Kenya[31]. Among children 1 to 4 years the reported rate was 15 deaths per 1,000 person years of observation for males and 14 deaths per 1,000 person years of observation for females.

Despite this overall decline in under-five mortality, the urban population growth in developing countries are a new threat to improving child survival[32]. In Kenya, there has been an overall decline in under 5 mortality though more faster and statistically significant in rural areas compared to urban areas[33]. In 2005, a study conducted in an informal settlement in Nairobi estimated an infant and under 5 mortality rate of 50.6 and 18.8 deaths per 1,000 person years of observation respectively [34].In 2015, the same study site reported mortality rates of 52.6 deaths per 1,000 person years in infants and 16.8 deaths per 1,000 person-years in children under 5 years between the years 2003 and 2012[35]. In Kibera informal settlement, a study to characterize under-five mortality rates between the years 2007 and 2010 reported that under-five mortality rate had significantly reduced. In the year 2010, the study estimated an infant mortality rate of 63.9 per 1,000 person years of observation. In under five, the study estimated a mortality rate of 16.2 per 1000 person years of observation[20].

2.1.2 Adult mortality

Globally, according to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) under-5 years death rate have declined faster than in adults. Globally, probability of dying (per 1,000) between the ages of 15 to 60 years was 140 in 2019 with Sub-Saharan Africa and Kenya having a higher probability of 218 and 233 per 1000 population respectively[36]. The Kenya demographic and heath survey conducted in 2014 estimated the age adjusted mortality rate for

males and women aged 15 to 49 years to be 4.78 and 3.72 deaths per 1,000 population respectively[24].

In 2016, the WHO global heath observatory reported the rates in Kenya as shown in table 1 below[31].

Table 1: WHO global heath observatory mortality rates per 1000 person years in Kenya.

Age Group	Male	Female
5-9 years	2.0	1.0
10-14 years	1.0	1.0
15-19 years	2.0	1.0
20-24 years	3.0	2.0
25-29 years	4.0	3.0
30-34 years	4.0	3.0
35-39 years	6.0	4.0
40-44 years	7.0	5.0
45-49 years	8.0	6.0
50-54 years	11.0	7.0
55-59 years	13.0	9.0
60-64 years	20.0	14.0
65-69 years	30.0	23.0
70-74 years	47.0	38.0
75-79 years	75.0	64.0
80-84 years	122.0	108.0
85+ years	226.0	205.0

In an informal settlement in Korogocho and viwandani in Nairobi mortality rates among adults, 15 to 49 years of age was 8.2 per 1,000 person years of observation among males and 4.0 per 1,000 person years of observation among females between the year 2006 and 2012[37].

In 2010, a study conducted in an informal settlement in Kibera, Kenya reported a mortality rate among persons 5 years and above of 4.0 deaths per 1,000 person-years of observation. Males and females had a rate of 6.9 and 5.0 deaths per 1,000 person years of observation respectively[20].

2.2 Cause specific mortality patterns and trends

2.2.1 Causes of children under-five year mortality

Among 5.9 million children under 5 years who died globally in 2015,17.8% died of preterm birth complications and 15.5% died of pneumonia making them the leading causes of death.[38].

In 2017,neonatal disorders(33.0%), lower-respiratory infection(15.0%) and diarrhoeal diseases(9.9%)were the leading causes of child mortality globally[29]. The leading CoD among under-5 in sub-Saharan Africa were neonatal disorders (25.3%). Globally, total under 5 year deaths from lower respiratory infections declined by 36.4% and 40.6% for diarrhoeal diseases between 2007 and 2017[39].In Kenya, the major causes of children under 5 years deaths in 2017 were neonatal disorders(28.3%), lower respiratory infection(15.9%)and diarrhoea(15.9%)[29].

In a slum in Kolkata India, a study determined that the main causes of death among children under 1 and children 1 to 4 years was diarrhoeal diseases (2.97 per 1000 person-years) and respiratory infections (0.86 per 100 person-years) respectively[14].

In Kenya, a study conducted in a slum in Nairobi reported Pneumonia, diarrhoeal diseases, and stillbirths as the leading causes of death among children under five[40].

2.2.2 Causes of adult mortality

Globally in 2017, the main cause of death among adults between the age of 15-49 years was ischemic heart disease while in sub-Saharan Africa including Kenya the main cause of death was HIV[41]. It is also evident that cancer leads to substantial deaths worldwide. Cancer related deaths are expected to grow rapidly over time[42].

In a study conducted in Ethiopia, the main causes adults aged 15 years and above deaths were tuberculosis, cerebrovascular diseases and accidental falls[43]. In Lusaka, Zambia, another study conducted in an urban area reported HIV/AIDS and malaria as the main causes of adults aged 15 years and above deaths[44].

In 2010, a study conducted in a slum in Nairobi, Kenya reported AIDS and tuberculosis combined as the top causes of death among persons 5 years and above accounting for about 50% of the mortality burden.[40]. Similarly in 2015, a study assessing the trends in causes of death among adolescents and persons 15 years and above an informal settlements between 2003 to 2012 reported tuberculosis (26.9%), injuries(20.9%), and HIV/AIDS(17.3%) as the overall leading cause of death.[45]. The study reported HIV/AIDS (34.0%) as the top cause of death in 2003. However, by 2012, TB was the major cause of death.

CHAPTER THREE

3.0 METHODS

3.1 Study area

This study was conducted in two villages; Soweto West and Gatwikira within an informal settlement in Kibera, Kenya. The Kibera informal settlement is situated 6.6 Kilometres South West of Nairobi central business district.

3.2 Study Design and Setting

This was a retrospective longitudinal open cohort study of all deaths of residents followed within the KEMRI and CDC population-based infectious disease surveillance (KEMRI Protocol #2761)) from 2009 to 2018 in 2 villages (Soweto West and Gatwikira) in the Kibera informal settlement, Nairobi, Kenya.

3.3 Study population

All residents followed within the KEMRI and CDC population-based infectious disease surveillance (KEMRI Protocol #2761)) from 2009 to 2018. The population is dynamic and ranges between 22,000-25,000 people in a 0.37 km^2 area.

3.3.1 Inclusion criteria

All mortality cases reported from participants who consented to participate in the surveillance under KEMRI Protocol #2761 as from 1st January 2009 to 31st December 2018 at Kibera surveillance area.

3.3.2 Exclusion criteria

All mortality cases from participants who did not consent to participate in the surveillance under KEMRI Protocol #2761 and mortality cases outside the surveillance area.

3.4 Sampling and Sample size

A census of all deaths with complete records that occurred in the study area formed the study population hence no sample determination technique was applied. The study aims at determining true patterns and trends between 1st January 2009 to 31st Dec 2018.

3.5 Data collection and management

The Kenya Medical Research Institute (KEMRI) in collaboration with the US Centers for Disease Control and Prevention (CDC) have conducted a population-based infectious disease surveillance (PBIDS) since 2006 in Kibera an urban informal settlement situated in Nairobi, Kenya[20].

In Kibera, Malaria is not endemic, but residents frequently travel to rural areas of the country, especially western Kenya where malaria is endemic[46]. Urban informal settlements like Kibera have reported a significantly higher adult prevalence of HIV of 12% compared to 6.5% for non-slum urban area[47].

As of 2018 an active population under surveillance was approximately 22,000 in a study area of 0.37 km^2. Active population in the PBIDS were defined as all persons residing in the study area for 4 months or more. They also included new-borns born to active mothers. Under the surveillance, household visits were regularly done to collect demographic data. Initially,

frequency of visits was every 2 weeks from Jan 2006 to Sept 2009; then every 1 week from Oct 2009 to May 2011; then every 2 weeks from June 2011 to May 2015 and then decreased to every 6 months since Oct 2015.Key demographic data gathered at household did not change over the surveillance period. Standardized questionnaire was administered to each household member as well as recording of demographic events such as births, deaths, in- and out-migrations in the household. With the reduced frequency of household visits, community reporters who were residents of the study area also provided continuous reports of pregnancies, births and deaths as they occurred.

Since 2009, reported deaths were followed up within a month by field workers who conducted verbal autopsy(VA) interviews of the next of kin or any adult respondent with sufficient knowledge of the deceased individual or health care worker who cared for the person at home or is familiar with the circumstances of the death [48,49]. The main objective was to record events surrounding the death.

Initially, VA interviews were conducted using standardized WHO 2007 verbal autopsy questionnaires until 2013 when an updated WHO 2012 questionnaires were introduced. Updated versions (WHO 2016 VA questionnaires) were later introduced in 2018[22].

Surveillance data were captured using standard questionnaires deployed in PDAs/netbooks or tablets. Data were uploaded into a password protected server daily and backups done. Data access were restricted to only authorized data personnel

3.6 Data analysis and presentation

Secondary data was extracted from the KEMRI and CDC population-based infectious disease surveillance (PBIDS) database. The data included all residents and all deaths occurring among residents of all ages at the time of death, between 1st January 2009 and 31st December 2018. Transformation and analyses were conducted using STATA release 13.1 software and R software for Windows (Release v3.6.1). Analyses on proportions and rates per 1,000 person years of observation (PYO) were conducted on age-specific and cause- specific mortality. Causes were grouped according to interVA model classification.

Age-specific mortality rate (ASMR) per 1000 person years of observation were given by: -

$$\frac{\text{Number of deaths in a given age group}}{\text{Sum of person-time at risk}} \text{ X } 1000 \qquad (3.1)$$

Individuals contributed to the person-time at risk denominator starting from 1st January, 2009 or from any later date of birth or in-migration, until 31st December, 2018, and they ceased to contribute to the denominator at death, refusal to participate in the study, out-migration, or the last surveillance confirmed visit. On out-migration they resumed contributing if they re-entered the surveillance area. Mortality rates were reported as deaths/1,000 person-years observation. The difference between the start and stop dates were divided by 365.25 to generate person-years of observation(pyo).

Cause specific mortality rate were computed. Cause of death (CoD) were obtained based on a Bayesian probabilistic model using the InterVA-4 software[48,49]. The model uses physician-

derived a *priori* probabilities of diseases and symptoms to calculate the probability of specific causes of death given reported symptoms as reported in a verbal autopsy (VA) interview. In other words, it obtains posterior probabilities of specific causes of death given an a priori probabilities of causes of death and signs/or symptoms. A Verbal autopsy is the process of interviewing family, friends or caregivers after a death has occurred to find out the circumstances of death.

The model makes use of Bayes' theorem and is given by:

$$P(C|I) = \frac{P(I|C)xP(C)}{P(I|C)xP(C) + P(I|!C)xP(!C)} \quad (3.2)$$

Where:

-P(C|I): Chance of a cause given an indicator

-P(I|C): Chance of reporting an indicator given a cause

-P(C): Chance of each cause in all deaths

-P(I|!C): Chance of an indicator given not a cause

Note that prior probabilities P(I|C) and P(C) are already available. These a *priori* probabilities used to generate posterior probabilities emanated from an expert panel that included practitioners from a range of medical specialisations and geographic regions[50].Probabilities are available for 62 possible causes of death. The InterVA model generates up to three most likely causes of death with their corresponding likelihoods.

Cause specific mortality fractions and rates were computed using the generated CoDs. Cause specific mortality fractions (CSMFs) refers to the proportion of deaths due to each cause.

Cause specific mortality rates (CSMR) were reported as the number of cause specific deaths per 1,000 person-years of observation. Therefore, given by:

$$\frac{\text{Number of deaths due to a specific cause}}{\text{Sum of person-time at risk}} \quad X\ 1000 \qquad (3.3)$$

Causes of death were ranked based on mortality rate per 1000 person–years observed. We stratified mortality analysis by sex and age groups. Cause specific mortality rates were adjusted for proportion of deaths with VA conducted.

Analyses to examine trends in age-specific mortality and main cause specific mortality rates per 1,000 person years of observation over time were done. Trends in mortality over time were identified and tested for statistical significance using a non-parametric test (Mann-Kendall trend test). This test does not require the dataset to conform to any probability distribution. This makes it a robust test. We checked for whether there was autocorrelation in the mortality rates by examining the autocorrelation (ACF) and partial autocorrelation function plots (PACF). In all plotted graphs, most vertical spikes in the ACF and PACF plots fell within the horizontal blue dotted lines(detailed results in Appendix 6.1).

H_o states: No statistically significant trend

H_1 states: There is a statistically significant trend

Each annualized age-and cause specific mortality trend line were reported as the Mann–Kendall

statistic, S.

S is given by:

$$\mathrm{S} = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign\left(x_j - x_k\right)$$

$$\begin{aligned} \text{where } sign\left(x_j - x_k\right) &= 1 \text{ if} \left(x_j - x_k\right) > 0 \\ &= 0 \text{ if} \left(x_j - x_k\right) = 0 \\ &= -1 \text{ if} \left(x_j - x_k\right) < 0 \end{aligned} \qquad (3.4)$$

Note that X_1, X_2, … X_n represents n data points and that X_j represents the data point at a particular time j. Note also that X_j is the following data value within an ordered time series and X_k is the data value coming before X_j.

The variance of S was computed. We computed a normalized test statistic, Z_s using the value of S. The variance S is given by:

$$\sigma^2 = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} (t_p - 1)(2t+5) \right] \qquad (3.5)$$

Z_s tests at 0.05 significance level were given by:

$$Z_s = \begin{cases} (S-1)/\sigma & for \quad S\rangle 0 \\ 0 & for \quad S = 0 \\ (S+1)/\sigma & for \quad S\langle 0 \end{cases}$$

(3.6)

If $Z_s > Z_{0.05}$ then the trend were statistically significant (reject H_0) otherwise accept.

3.7 Limitation of the study

Over the years, efforts have been made to improve the quality of Verbal autopsy (VA) data. However, factors like timing of interview or skills of interviewer can introduce bias. Therefore, causes of death generated from this study need to be treated as a supplement to data obtained from an effective civil registration system. Nonetheless, VA data remains a plausible means of generating causes of death particularly in low- and middle-income countries like Kenya which lack an effective civil registration system.

This study was done within only two villages in Kibera informal settlements therefore generalization of the study results should be done with caution. However, the study intends to give an insight into mortality within informal settlements.

3.8 Ethical consideration

Ethical approval was obtained from the University of Nairobi/Kenyatta National Hospital ethical review committee **(Proposal No: P372/07/2020).** Permission to access the surveillance database was sought from the Principal investigator.

CHAPTER FOUR

4.0 RESULTS

4.1 Data

A total of 1134 deaths were registered from January 2009 to December 2018 (Figure 1). Of these total deaths, 774 (68.2%) had a complete Verbal autopsy (VA) conducted. A total of 735 (95.0%) deaths were assigned a cause of death through the Bayesian probabilistic model (InterVA model)

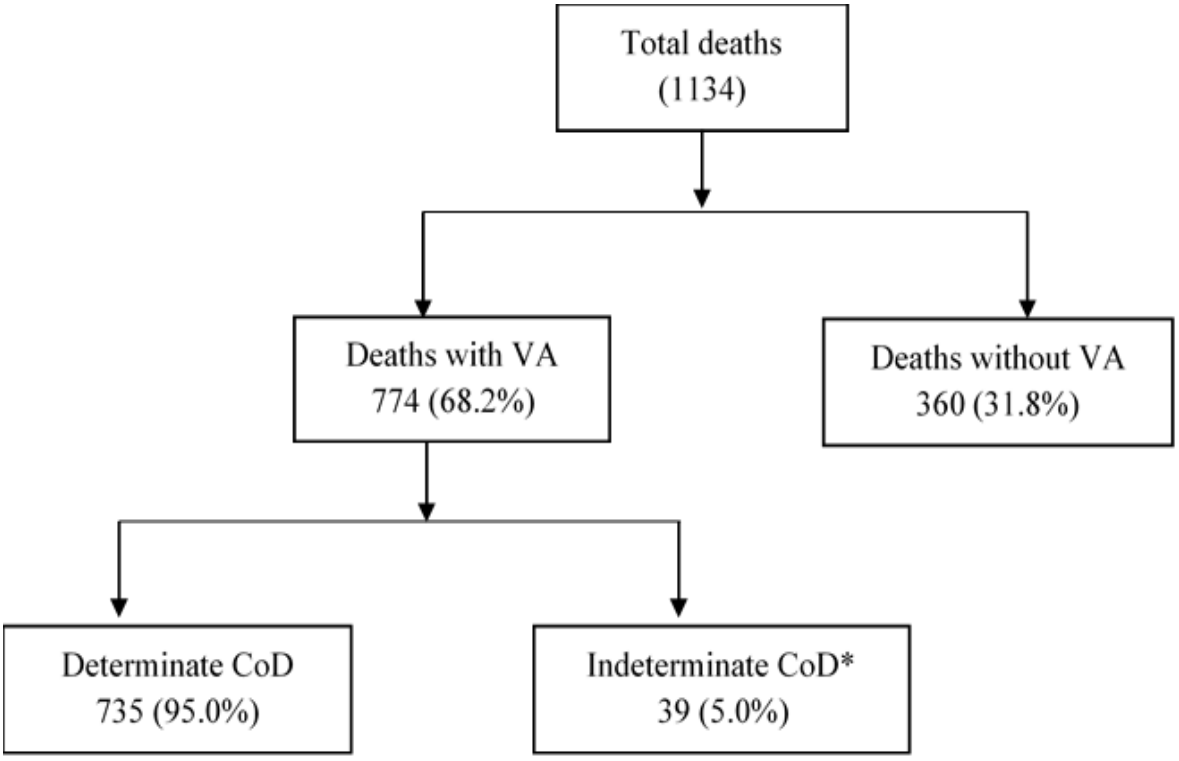


Figure 1: Flow chart of the deaths recorded in Kibera PBIDS, Kenya from January 2009 to December2018. *****Deaths that could not be assigned a cause of death due to incomplete data; CoD=Cause of Deaths; VA=Verbal Autopsy

4.1 Age-specific mortality rates (ASMR)

There were 256,445 person years of observation (pyo) of follow-up during the 10-year period of surveillance (Table 2). The overall crude mortality rate was 4.4 per 1000 pyo (95% Confidence Interval, CI; 4.2 –4.7).The highest mortality rate was observed in children under 1 year (41.5 per 1000 pyo; 95% CI 36.6–46.9) and persons aged 65years and above (32.6 per 1000 pyo; 95% CI 21.5–47.5) and lowest in persons aged 5-14years (1.1 per 1000 pyo; 95% CI 0.9–1.4).Males had a higher all-cause mortality compared to females; 5.2(95% CI 4.8–5.7) vs. 3.6 (95% CI 3.3–4.0) per 1000 pyo.

Table 2: Number of deaths, proportion of deaths with verbal autopsy and mortality rates by age, sex and year,2009 – 2018.

Characteristics	# of deaths	PYO	Mortality rate (95% CI)	# of VA done		Determinate CoD	
Age Group				n	%	n	%
<1 year	260	6263.1	41.5 (36.6-46.9)	198	76.2	174	87.9
1–4 years	155	31695.9	4.9 (4.2-5.7)	104	67.1	101	97.1
5–14 years	82	73523.5	1.1 (0.9-1.4)	51	62.2	48	94.1
15–49 years	507	134988.5	3.8 (3.4-4.1)	331	65.3	323	97.6
50–64 years	103	9147.0	11.3 (9.2-13.7)	68	66	67	98.5
65 years +	27	827.4	32.6 (21.5-47.5)	22	81.5	22	100
Sex							
Female	478	131306.0	3.6 (3.3-4.0)	318	66.5	302	95
Male	656	125139.5	5.2 (4.8-5.7)	456	69.5	433	95
Year							
2009	173	25792.3	6.7 (5.7-7.8)	98	56.6	96	98
2010	185	28099.7	6.6 (5.7-7.6)	106	57.3	101	95.3
2011	156	27811.8	5.6 (4.8-6.6)	110	70.5	99	90
2012	125	27033.2	4.6 (3.8-5.5)	91	72.8	84	92.3
2013	111	26570.2	4.2 (3.4-5.0)	74	66.7	71	95.9
2014	111	26910.6	4.1 (3.4-5.0)	92	82.9	86	93.5
2015	70	24173.5	2.9(2.3-3.7)	49	70	48	98
2016	57	23638.6	2.4 (1.8-3.1)	39	68.4	37	94.9
2017	84	23193.1	3.6 (2.9-4.5)	70	83.3	68	97.1
2018	62	23222.4	2.7 (2.0-3.4)	45	72.6	45	100
All	1134	256445.4	4.4 (4.2-4.7)	774	68.3	735	95

4.2 Cause-specific mortality fractions (CSMF)

Based on the Bayesian probability model (interVA model), most deaths were attributed to acute respiratory infections including pneumonia (18.1%) followed by HIV/AIDS related deaths (12.8%), Pulmonary tuberculosis (6.9%) and then malaria (5.9%). In children under 5 years (Figure 2), the most common cause of death (CoD) observed were acute respiratory infections including pneumonia (34.0%) and Malaria (8.9%). In persons 5 years and above (Figure 2), the most common CoD observed were HIV/AIDS related deaths (18.2%) and pulmonary tuberculosis (11.4%).

On grouping the causes of deaths (Figure 3), communicable diseases (60.6%) were the most common CoD observed among children under 5 years followed by neonatal causes (19.0%). Similarly, communicable diseases (45.8%) were the most common CoD observed in persons 5 years and above followed by non-communicable diseases (34.4%) and Injuries (8.7%).

Neonatal causes of death were mostly due to neonatal pneumonia (28.3%), congenital malformation (18.3%), neonatal sepsis (16.7%), prematurity (16.7%). Deaths due to non-communicable diseases in persons 5 years and above and children under 5 years were mostly due to other and unspecified cardiac diseases (21.7%) and acute abdomen (50.0%) respectively.

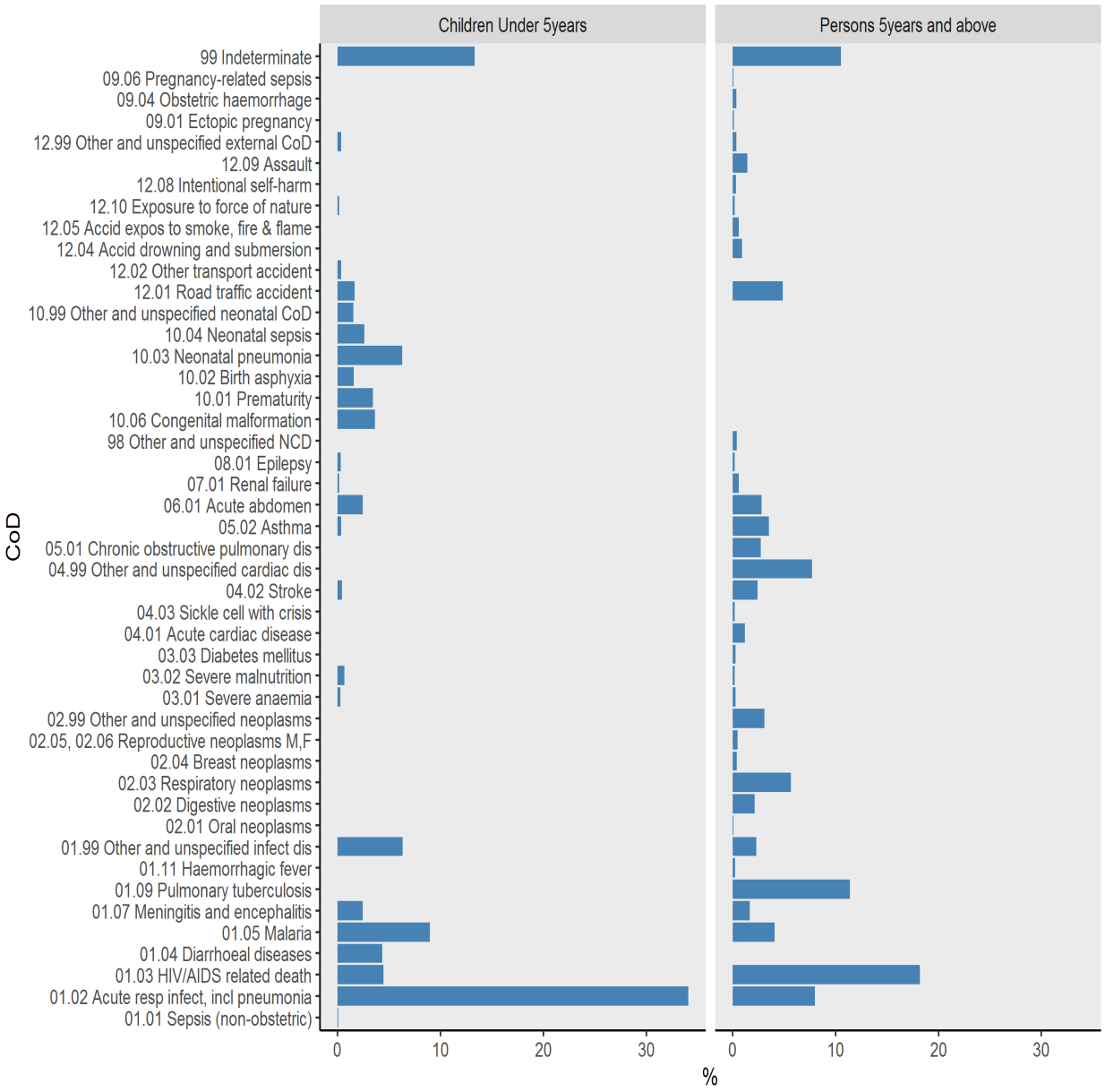


Figure 2: Generalized causes of death by age group in Kibera PBIDS, Kenya,2009-2018.

CoD=Cause of death; NCD=Non-communicable diseases

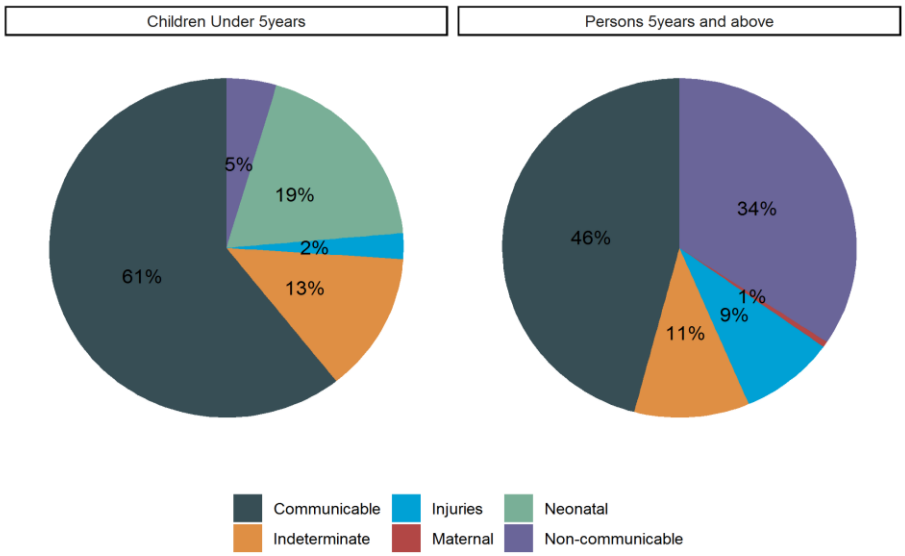


Figure 3: Overall grouped cause of death by age group in Kibera PBIDS, Kenya,2009-2018.

4.3 Cause-specific mortality rates (CSMR)

The top 3 causes of death with the highest cause specific mortality rates (CSMR) among children under 5 years (Table 3) were acute respiratory infection including pneumonia (3.84 per 1,000 pyo), malaria (1.05 per 1,000 pyo) and other and unspecified infectious diseases (0.76 per 1,000 pyo). Among persons 5 years and above (Table 4), the top 3 CoD with the highest CSMR were HIV/AIDS related deaths (0.61 per 1,000 pyo), pulmonary tuberculosis (0.43 per 1,000 pyo) and acute respiratory infection including pneumonia (0.29 per 1,000 pyo). Acute respiratory infection including pneumonia deaths (Table 5) were most common in children under 1 year (14.47 per 1,000 pyo). HIV/AIDS related deaths were most common within the age group of 50-64 years (1.49 per 1,000 pyo).

Table 3: Children under 5 years adjusted cause specific mortality rates (CSMR) by year,2009 – 2018.

	2009	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*Total*
PYO	4833.7	5097.3	4752.4	4317.1	3833.9	3524.3	2982.2	2924.6	2884.5	2808.8	37958.9
Acute abdomen	0.95	0.31	0.55	0.00	0.00	0.00	0.00	0.50	0.39	0.00	0.29
Acute resp infect incl. pneumonia	5.06	5.30	5.81	4.30	4.14	3.51	1.15	1.49	2.70	0.61	3.84*
Asthma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.04
Birth asphyxia	0.00	0.00	0.28	0.00	0.32	0.00	0.00	0.50	0.00	1.21	0.18
Congenital malformation	0.00	0.93	0.55	0.57	0.32	0.96	0.00	0.00	0.00	0.00	0.40
Diarrheal diseases	1.26	0.00	0.55	0.57	0.64	0.64	0.00	0.00	0.00	1.21	0.51*
Epilepsy	0.00	0.00	0.00	0.29	0.00	0.32	0.00	0.00	0.00	0.00	0.07
HIV/AIDS related death	1.58	0.93	0.55	0.29	0.00	0.00	0.57	0.50	0.00	0.61	0.51*
Indeterminate	0.63	1.25	2.49	1.15	0.32	1.28	0.00	0.50	0.77	0.00	0.98
Malaria	3.16	1.87	0.28	1.15	0.64	0.64	0.00	0.50	1.16	0.00	1.05*
Meningitis and encephalitis	0.32	0.31	0.28	0.29	0.32	0.00	0.57	0.50	0.39	0.00	0.29
Neonatal pneumonia	0.32	1.87	0.55	0.86	0.32	0.64	0.00	0.00	0.77	0.00	0.62
Neonatal sepsis	0.32	1.25	0.28	0.86	0.00	0.00	0.57	0.00	0.00	0.00	0.36
Other and unspecified external CoD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.04
Other and unspecified infect diseases	2.21	1.56	0.55	0.86	0.96	0.32	0.00	0.00	0.00	0.00	0.76*
Other and unspecified neonatal CoD	0.32	0.31	0.55	0.00	0.32	0.64	0.00	0.00	0.00	0.00	0.25
Other transport accident	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.04
Prematurity	0.32	0.00	0.00	0.29	0.32	0.64	0.57	0.00	0.77	1.21	0.36
Road traffic accident	0.32	0.00	0.28	0.29	0.00	0.32	0.00	0.50	0.00	0.00	0.18
Severe anaemia	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Severe malnutrition	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.61	0.07
Stroke	0.00	0.00	0.28	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.07

***** Top five cause of death (CoD)with the highest CSMR; PYO; Person years of observation

Table 4: Persons 5 years and above adjusted cause specific mortality rates (CSMR) by year,2009 – 2018.

	2009	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*Total*
PYO	20958.6	23002.4	23059.4	22716.0	22736.3	23386.3	21191.2	20714.0	20308.7	20413.5	218486.4
Accidental drowning and submersion	0.00	0.00	0.00	0.26	0.07	0.00	0.00	0.00	0.00	0.06	0.04
Accidental exposure to smoke fire &flame	0.00	0.00	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.06	0.02
Acute abdomen	0.20	0.08	0.26	0.00	0.07	0.00	0.26	0.07	0.06	0.00	0.10
Acute cardiac disease	0.10	0.08	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.13	0.04
Acute resp infect incl. pneumonia	0.29	0.49	0.33	0.20	0.22	0.32	0.13	0.28	0.48	0.06	0.29*
Assault	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.14	0.06	0.13	0.06
Asthma	0.00	0.00	0.33	0.33	0.15	0.16	0.00	0.14	0.12	0.00	0.13
Breast neoplasms	0.00	0.00	0.00	0.00	0.07	0.05	0.00	0.00	0.00	0.00	0.01
Chronic obstructive pulmonary disease	0.29	0.25	0.00	0.13	0.22	0.27	0.07	0.00	0.00	0.00	0.12
Diabetes mellitus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01
Digestive neoplasms	0.00	0.00	0.00	0.07	0.07	0.11	0.13	0.21	0.00	0.13	0.08
Ectopic pregnancy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01
Epilepsy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01
Exposure to force of nature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01
HIV/AIDS related death	1.07	0.82	0.65	0.59	0.66	0.69	0.13	0.28	0.85	0.31	0.61*
Haemorrhagic fever	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.01
Indeterminate	0.00	0.08	0.13	0.20	0.15	0.11	0.07	0.07	0.00	0.00	0.08
Intentional self-harm	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01
Malaria	0.20	0.33	0.26	0.07	0.22	0.11	0.07	0.07	0.06	0.06	0.14
Meningitis and encephalitis	0.00	0.08	0.07	0.13	0.07	0.00	0.20	0.00	0.00	0.06	0.06
Obstetric haemorrhage	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Other and unspecified NCD	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.06	0.02
Other and unspecified cardiac disease	0.49	0.41	0.59	0.26	0.36	0.21	0.13	0.07	0.12	0.13	0.27
Other and unspecified external CoD	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.06	0.00	0.03
Other and unspecified infect disease	0.20	0.00	0.00	0.07	0.07	0.11	0.13	0.00	0.18	0.00	0.08
Other and unspecified neoplasms	0.20	0.25	0.07	0.20	0.07	0.21	0.07	0.07	0.00	0.00	0.11

Pregnancy-related sepsis	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Pulmonary tuberculosis	0.98	0.74	0.59	0.26	0.44	0.21	0.46	0.14	0.36	0.25	0.43*
Renal failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.00	0.02
Reproductive neoplasms MF	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.06	0.00	0.01
Respiratory neoplasms	0.29	0.41	0.13	0.33	0.22	0.53	0.13	0.00	0.06	0.00	0.22
Road traffic accident	0.00	0.33	0.13	0.00	0.07	0.11	0.13	0.21	0.30	0.13	0.15
Severe malnutrition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01
Sickle cell with crisis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01
Stroke	0.00	0.16	0.07	0.00	0.00	0.00	0.13	0.07	0.06	0.38	0.09

***** Top three cause of death (CoD)with the highest CSMR; PYO; Person years of observation

Table 5: Adjusted cause specific mortality rates (CSMR) by age group,2009 – 2018.

	<1Yrs	*1-4Yrs*	*5-14Yrs*	*15-49Yrs*	*50-64Yrs*	*65Yrs+*	*Total*
PYO	6263.1	31695.9	73523.5	134988.5	9147.0	827.4	256445.4
Accidental drowning and submersion	0.00	0.00	0.02	0.06	0.00	0.00	0.03
Accidental exposure to smoke fire & flame	0.00	0.00	0.04	0.00	0.17	0.00	0.02
Acute abdomen	0.63	0.24	0.04	0.09	0.50	1.48	0.13
Acute cardiac disease	0.00	0.00	0.00	0.03	0.50	0.00	0.03
Acute respiratory infection incl. pneumonia	14.47	1.74	0.22	0.23	1.16	5.93	0.84
Assault	0.00	0.00	0.00	0.09	0.00	0.00	0.05
Asthma	0.00	0.05	0.00	0.20	0.00	1.48	0.11
Birth asphyxia	1.05	0.00	0.00	0.00	0.00	0.00	0.03
Breast neoplasms	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Chronic obstructive pulmonary disease	0.00	0.00	0.00	0.14	0.83	0.00	0.10
Congenital malformation	2.31	0.00	0.00	0.00	0.00	0.00	0.06
Diabetes mellitus	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Diarrheal diseases	1.68	0.28	0.00	0.00	0.00	0.00	0.08
Digestive neoplasms	0.00	0.00	0.00	0.08	0.50	1.48	0.06
Ectopic pregnancy	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Epilepsy	0.42	0.00	0.00	0.01	0.00	0.00	0.02
Exposure to force of nature	0.00	0.00	0.00	0.01	0.00	0.00	0.01

HIV/AIDS related death	0.84	0.47	0.11	0.82	1.49	1.48	0.58
Haemorrhagic fever	0.00	0.00	0.02	0.01	0.00	0.00	0.01
Indeterminate	5.03	0.14	0.07	0.09	0.17	0.00	0.22
Intentional self-harm	0.00	0.00	0.02	0.01	0.00	0.00	0.01
Malaria	2.52	0.80	0.13	0.15	0.17	0.00	0.28
Meningitis and encephalitis	0.63	0.24	0.02	0.07	0.33	0.00	0.10
Neonatal pneumonia	3.56	0.00	0.00	0.00	0.00	0.00	0.10
Neonatal sepsis	2.10	0.00	0.00	0.00	0.00	0.00	0.06
Obstetric haemorrhage	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Other and unspecified NCD	0.00	0.00	0.00	0.00	0.33	1.48	0.02
Other and unspecified cardiac disease	0.00	0.00	0.00	0.31	1.49	4.45	0.22
Other and unspecified external CoD	0.00	0.05	0.04	0.00	0.33	0.00	0.03
Other and unspecified infectious disease	1.89	0.56	0.17	0.02	0.17	0.00	0.18
Other and unspecified neonatal CoD	1.47	0.00	0.00	0.00	0.00	0.00	0.04
Other and unspecified neoplasms	0.00	0.00	0.00	0.14	0.17	4.45	0.09
Other transport accident	0.00	0.05	0.00	0.00	0.00	0.00	0.01
Pregnancy-related sepsis	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Prematurity	2.10	0.00	0.00	0.00	0.00	0.00	0.06
Pulmonary tuberculosis	0.00	0.00	0.00	0.57	1.32	4.45	0.35
Renal failure	0.00	0.00	0.00	0.03	0.00	0.00	0.02
Reproductive neoplasms MF	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Respiratory neoplasms	0.00	0.00	0.00	0.24	1.16	4.45	0.18
Road traffic accident	0.42	0.14	0.20	0.14	0.00	0.00	0.15
Severe anaemia	0.00	0.05	0.00	0.00	0.00	0.00	0.01
Severe malnutrition	0.00	0.09	0.00	0.01	0.00	0.00	0.02
Sicklecell with crisis	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Stroke	0.42	0.00	0.00	0.10	0.50	1.48	0.09

PYO; Person years of observation

4.3 Trends in mortality rates

Overall, all-cause mortality rate significantly declined (Kendall τ=-0.87, p<0.001) over time from 6.7 per 1000 pyo (95% CI 5.7–7.8) in 2009 to 2.7 per 1000 pyo (95% CI 2.0–3.4) in 2018. This decline in all-cause mortality rates was observed by age-group and sex (Figure 4 and Figure 5). Among children under 5 years, all-cause mortality rate significantly declined (Kendall τ=-0.73, p=0.004) from 16.8 per 1000 pyo (95% CI 13.3–20.8) in 2009 to 6.1 per 1000 pyo (95% CI 3.5–9.7) in 2018. A decline was equally observed among persons 5 years and above (Kendall τ=-0.74, p=0.005) from 4.4 per 1000 pyo (95% CI 3.5–5.4) in 2009 to 2.2 per 1000 pyo (95% CI 1.6–2.9) in 2018. Likewise, a decrease in all-cause mortality was observed in both females (Kendall τ=-0.70, p=0.007) and males (Kendall τ=-0.76, p=0.003). Despite this decline in all-cause mortality rates, males had consistently higher all-cause mortality rates overtime than females except in 2011.

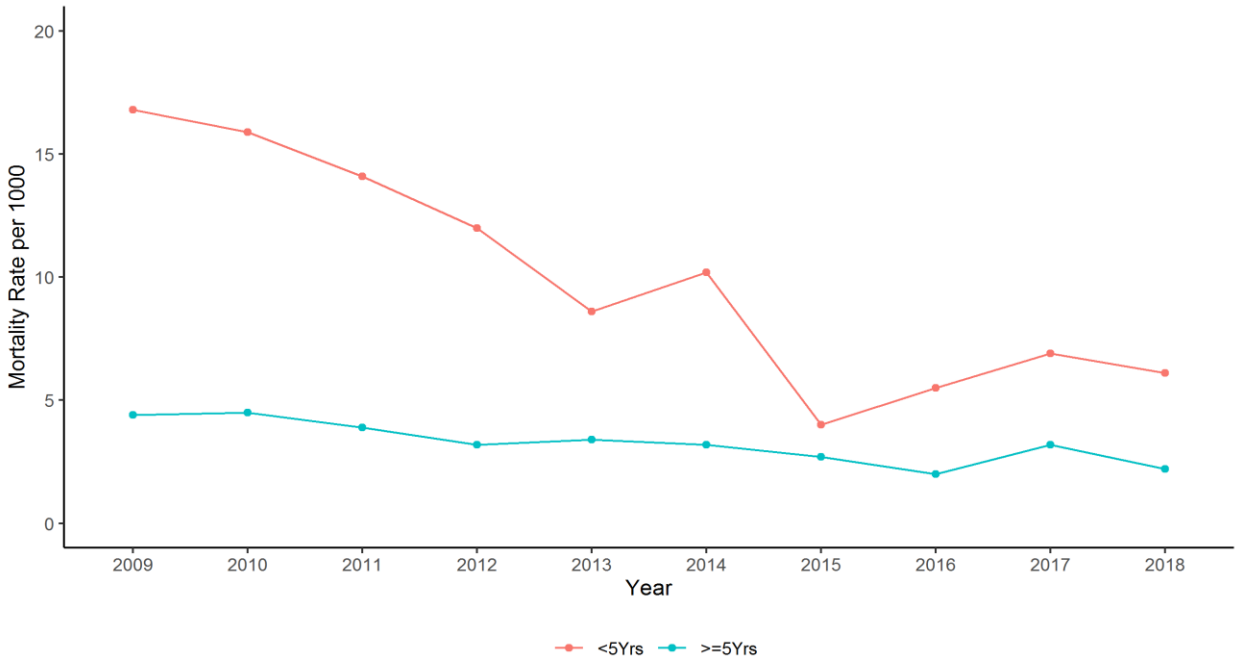


Figure 4: All-cause mortality rates per 1000 pyo by age group in Kibera PBIDS, Kenya, 2009-2018.

Figure 5: All-cause mortality rates per 1000 pyo by sex in Kibera PBIDS, Kenya, 2009-2018.

During the study period, acute respiratory infection including pneumonia deaths remained the leading CoD among children under 5 years (Figure 6). However, there was a significant decline in CSMR (Kendall τ=-0.73, p=0.004) from 5.06 per 1,000 pyo in 2009 to 0.61 per 1,000 pyo in 2018.Similarly, during the study period, HIV/AIDS related deaths remained the leading CoD among persons 5 years and above (Figure 6). However, there was a decline from 1.07 per 1,000 pyo in 2009 to 0.31 per 1,000 pyo in 2018 though this was not statistically significant (Kendall τ=-0.33, p=0.21). On the other hand, causes of death due to pulmonary tuberculosis among persons 5 years and above significantly declined (Kendall τ=-0.60, p=0.02).

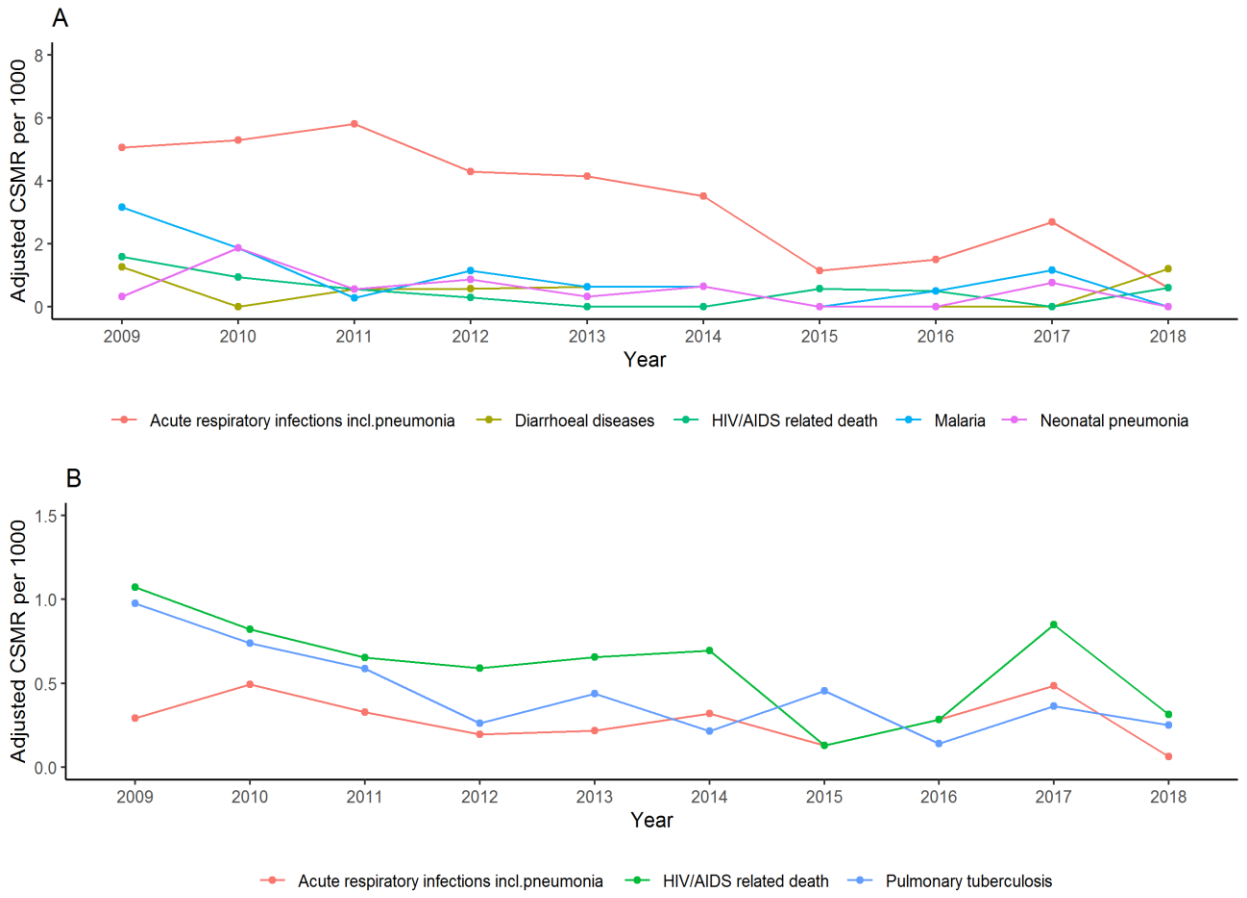


Figure 6: Adjusted cause-specific mortality rate for top CoD by age group in Kibera PBIDS, Kenya,2009-2018.**A:** Children under 5 years; **B:** Persons 5 years and above; CSMR=Cause specific mortality rate

Table 6: Mann-Kendall's two tailed test summary by generalized cause of death and age group

	<5 Years		*>5Years*	
Generalized Cause of Death	tau†	P-value	tau†	P-value
Acute respiratory infections Inc. Pneumonia	-0.733	**0.0042***	-0.289	0.28313
Diarrheal diseases	-0.0716	0.85289		
HIV/AIDS related death	-0.322	0.2379	-0.333	0.2105
Malaria	-0.449	0.088		
Neonatal pneumonia	-0.322	0.2379		
Pulmonary tuberculosis			-0.6	**0.020045***

*† Kendall's Tau statistic; *P-value<0.05*

Overall (Figure 7), there was a significant decline in mortality due to communicable diseases among children under 5 years (Kendall τ=-0.73, p=0.004).

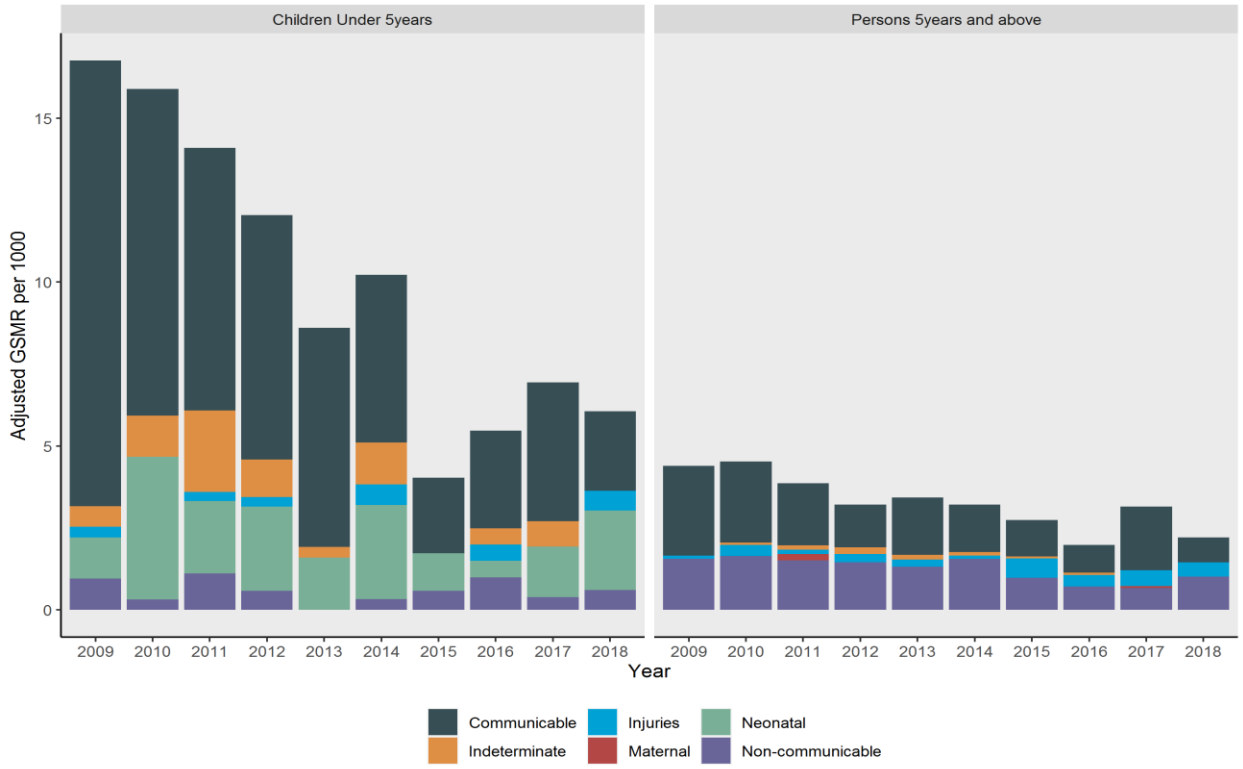


Figure 7: Adjusted group-specific mortality rate by year and age group in Kibera PBIDS, Kenya,2009-2018.GSMR=Group-specific mortality rate

Table 7: Mann-Kendall's two tailed test summary by grouped cause of death and age group

	<5 Years		*≥5Years*	
Grouped Cause of Death	tau†	P-value	tau†	P-value
Communicable	-0.733	**0.0042***	-0.289	0.28313
Neonatal	0.381	0.18609		
Injuries	0.447	0.16373	0.0609	0.91135
Non-communicable	-0.328	0.2489	-0.414	0.12275
Maternal			0.348	0.2963

*† Kendall's Tau statistic; *P-value<0.05*

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Age-specific mortality rates

Over the 10-year period, age specific mortality rates declined in Kibera informal settlements, with a reduction of ~64% in children aged <5 and ~50% among individuals ≥5 years. This is consistent with other studies which have reported decline in mortality rates[30,51].Despite this decline, mortality rate among <1-year olds were more than 8 times that of children aged 1-4 years. This is similar to a study conducted in a slum in India which reported higher mortality rates among children under 1 year[14]. Moreover, males died at a higher rate than females, despite declines in mortality rates over time in both sexes. This is consistent with a multisite study which reported higher mortality rates in males compared to females[37]. According to this study under-5 years death rate have declined faster than in adults. Similarly, according to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) under-5 years death rate have declined faster than in adults. In general, decline in mortality rates was primarily driven by reductions in deaths due to communicable diseases especially in children under 5 years. However, some infectious causes such as HIV/AIDS have remained stubbornly persistent

5.1.2 Mortality rates due to Acute respiratory infection (ARI) including pneumonia

In this study, acute respiratory infection (ARI) including pneumonia were the leading cause of death among children under 5 years. Several studies have similarly highlighted respiratory infections as a leading cause of morbidity and mortality in informal settlements[40,52].This has

been attributed to factors such as indoor air pollution and overcrowding, which are a characteristic of informal settlements, that favour spread of respiratory pathogens [53].

In this study, the burden of acute respiratory infections including pneumonia among children under the age of five declined during the study period. However, neonatal pneumonia remained fairly stable. This decline in acute respiratory infections including pneumonia deaths could be attributed to changes in health systems over time. Moreover, the introduction of pneumococcal conjugate vaccine (PCV10) in Kenya in January 2011 as part of the national immunisation schedule could have also led to this decline. Studies have reported a decrease in incidence of invasive pneumococcal disease (IPD) caused by vaccine serotypes due to the introduction of PCV10 in Kenya[54,55].In this study, mortality rates due to acute respiratory infections including pneumonia did not decline in persons 5 years and above as much as it was observed among children under 5 years. This is in contrast to another study in Kenya which reported a decline in pneumococcal pneumonia in adults due to indirect effect of PCV10[56].Continued stability in pneumonia deaths could be attributed to the high burden of HIV/AIDS and undetected TB among adults in this setting.

5.1.3 Mortality rates due to HIV/AIDS and TB

In this study there was a decline in mortality rates due to HIV/AIDS and TB among persons 5 years and above. However, these remained the leading cause of death. This is similar to the global trend in decline of HIV/AIDS and TB related mortality [57].Despite this decline, studies have however reported HIV/AIDS and TB as still major causes of adult deaths in sub-Saharan Africa and particularly among people living in informal settlements[58,45].

In Kenya, several efforts have been made towards prevention, treatment and control of HIV/AIDS. For example, In 2017,the national adult HIV prevalence rate had reduced to 4.9% from 6.0% in 2006 and the adult ART coverage was estimated at 75% [59].Despite these efforts the burden of HIV/AIDS and TB is relatively high in urban informal settlements[60,61].

The high burden of HIV could be attributed to risky sexual practices e.g. early age at sexual debut among slum residents[62].The high TB burden could be as a result of the high HIV burden in this setting, resulting in suppressed immunity, hence, susceptibility to opportunistic infections. Informal settlements are also characterised by high population density which are known to promote spread of respiratory illnesses.

5.1.4 Mortality rates due to Malaria

In this study, malaria also stood out as an important cause of death(CoD) among children under 5 years despite Nairobi, Kenya being considered a low-risk area for malaria transmission[63]. This transmission of malaria may be due to residents travelling to other parts of rural western Kenya where malaria is endemic. Human migration has been reported as one of the factors contributing to the re-emergence of malaria[64].

A study looking at malaria parasitaemia among febrile patients seeking care at an outpatient clinic within Kibera informal settlement determined that 23% of children aged 1–4 years were malaria positive by smear and majority of patients who were malaria positive had travelled to western Kenya[46]. The study reported that 34% had reported no travel history therefore raising the possibility of local malaria transmission.

5.1.5 Mortality rates due to Non-communicable diseases (NCDs)

In this study, injuries and other non-communicable diseases were major contributors to mortality in the adult population. Sub-Saharan Africa is undergoing a rapid change in epidemiology characterised by a move from communicable disease-burden to NCDs burden[65].Our study is consistent with several studies which have reported an increase in deaths due to injuries and non-communicable diseases among adults living in informal settlements[14,16,45].Non communicable diseases have been attributed to a rise in risk factors such as unhealthy diet, sedentary lifestyle, harmful alcohol consumption and tobacco use that have been on the rise in urban informal settlements in Africa[66]. In another study in an informal settlement highlighted prevalence in overweight and obesity and the strong preference for a larger body size among adults in the slums of Nairobi[67].

5.2 Limitations of the study

Over the years, efforts have been made to improve the quality of Verbal Autopsy (VA) data. However, it is important to highlight that factors like timing of interview, skills of interviewer and approaches used to derive probable cause of death can influence the interpretation of VA data [68]. In addition, Misclassification errors occur in all forms of cause-of-death assignment, including the Bayesian probabilistic modelling (InterVA model) approach that was used in this study. We acknowledge that there is a possibility of misclassification bias by the Bayesian probabilistic model (InterVA model). This might have resulted in the overestimation of malaria deaths in this study.

5.3 Conclusion

In conclusion, overall age specific mortality rates declined over time. Despite declines in several important infectious causes of death, communicable diseases have remained to be the leading causes of death in this community. In addition, injuries and other NCDs are a major cause of adult mortality. High disease burden in informal settlements may threaten progress towards the Sustainable Development Goals.

5.4 Recommendations

Despite progress in reducing mortality rates, this study has highlighted deaths due to infectious and non-infectious causes where further intervention are needed. Interventions such as improving housing conditions for example are needed to bring down pneumonia deaths in older children and adults. There is also need to better understand the reasons for continued HIV/AIDS and TB burden in informal settlements such as Kibera. It is also important for clinicians to consider malaria as a potential cause of illness among children, even in low-risk areas such as Kibera. Moreover, effective evidence-informed policies are still needed to address prevention and control of injuries and other NCDs in informal settlements.

References

1. Setel PW, Macfarlane SB, Szreter S, Mikkelsen L, Jha P, Stout S, et al. A scandal of invisibility: making everyone count by counting everyone. 2007; 9.

2. Phillips DE, Lozano R, Naghavi M, Atkinson C, Gonzalez-Medina D, Mikkelsen L, et al. A composite metric for assessing data on mortality and causes of death: the vital statistics performance index. Popul Health Metrics. 2014;12: 14. doi:10.1186/1478-7954-12-14

3. Mathers CD, Fat DM, Inoue M, Rao C, Lopez AD. Counting the dead and what they died from: an assessment of the global status of cause of death data. Bulletin of the World Health Organization. 2005; 10.

4. Home .:. Sustainable Development Knowledge Platform. [cited 15 Apr 2020]. Available: https://sustainabledevelopment.un.org/

5. World Health Organization. World health statistics 2019.pdf.

6. Mikkelsen L, Phillips DE, AbouZahr C, Setel PW, de Savigny D, Lozano R, et al. A global assessment of civil registration and vital statistics systems: monitoring data quality and progress. The Lancet. 2015;386: 1395–1406. doi:10.1016/S0140-6736(15)60171-4

7. Dicker D, Nguyen G, Abate D, Abate KH, Abay SM, Abbafati C, et al. Global, regional, and national age-sex-specific mortality and life expectancy, 1950–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018;392: 1684–1735. doi:10.1016/S0140-6736(18)31891-9

8. Fottrell E. Dying to count: mortality surveillance in resource-poor settings. Global Health Action. 2009;2: 1926. doi:10.3402/gha.v2i0.1926

9. Ye Y, Wamukoya M, Ezeh A, Emina JBO, Sankoh O. Health and demographic surveillance systems: a step towards full civil registration and vital statistics system in sub-Sahara Africa? BMC Public Health. 2012;12: 741. doi:10.1186/1471-2458-12-741

10. Kenya Verbal Autopsy Standards & Guidelines(2019).

11. Civil Registration and Vital Statistics System – End-of-Project Assessment Report — MEASURE Evaluation. [cited 24 Apr 2020]. Available: https://www.measureevaluation.org/resources/publications/tr-17-220

12. English M, Mwaniki P, Julius T, Chepkirui M, Gathara D, Ouma PO, et al. Hospital Mortality – a neglected but rich source of information supporting the transition to higher quality health systems in low and middle income countries. BMC Med. 2018;16: 32. doi:10.1186/s12916-018-1024-8

13. Turin DR. Health Care Utilization in the Kenyan Health System: Challenges and Opportunities. Inquiries Journal/Student Pulse. 2010;2. Available: http://www.inquiriesjournal.com/a?id=284

14. Kanungo S, Tsuzuki A, Deen JL, Lopez AL, Rajendran K, Manna B, et al. Use of verbal autopsy to determine mortality patterns in an urban slum in Kolkata, India. Bull World Health Organ. 2010;88: 667–674. doi:10.2471/BLT.09.073742

15. Byass P. Who Needs Cause-of-Death Data? PLoS Medicine. 2007;4: 2.

16. Oti SO, van de Vijver S, Kyobutungi C. Á Trends in non-communicable disease mortality among adult residents in Nairobi's slums, 2003 2011: applying InterVA-4 to verbal autopsy data. : 9.

17. Ezeh A, Oyebode O, Satterthwaite D, Chen Y-F, Ndugwa R, Sartori J, et al. The history, geography, and sociology of slums and the health problems of people who live in slums. The Lancet. 2017;389: 547–558. doi:10.1016/S0140-6736(16)31650-6

18. Population and Health Dynamics in Nairobi's Informal Settlements.pdf.

19. Kenya-The unseen majority2009.pdf.

20. Olack B, Feikin DR, Cosmas LO, Odero KO, Okoth GO, Montgomery JM, et al. Mortality Trends Observed in Population-Based Surveillance of an Urban Slum Settlement, Kibera, Kenya, 2007–2010. Vermund SH, editor. PLoS ONE. 2014;9: e85913. doi:10.1371/journal.pone.0085913

21. Nahlen BL, Ter Kuile FO, Orago ASS, Gimnig JE, Hawley WA, Kolczak MS, et al. Comparison of government statistics and demographic surveillance to monitor mortality in children less than five years old in rural western kenya. The American Journal of Tropical Medicine and Hygiene. 2003;68: 30–37. doi:10.4269/ajtmh.2003.68.30

22. Bowden S, Braker K, Checchi F, Wong S. Implementation and utilisation of community-based mortality surveillance: a case study from Chad. Confl Health. 2012;6: 11. doi:10.1186/1752-1505-6-11

23. Groenewald P, Bradshaw D, Daniels J, Zinyakatira N, Matzopoulos R, Bourne D, et al. Differential health needs of the population in Cape Town, South Africa: Local-level mortality surveillance in resource-limited settings: a case study of the City of Cape Town highlights disparities in health. Bull World Health Org. 2010;88. doi:10.2471/BLT.09.069435

24. Kenya Demographic and Health Survey(2014).

25. D'Ambruoso L, Boerma T, Byass P, Fottrell E, Herbst K, Källander K, et al. The case for verbal autopsy in health systems strengthening. The Lancet Global Health. 2017;5: e20–e21. doi:10.1016/S2214-109X(16)30332-1

26. Feikin DR, Olack B, Bigogo GM, Audi A, Cosmas L, Aura B, et al. The Burden of Common Infectious Disease Syndromes at the Clinic and Household Level from Population-Based Surveillance in Rural and Urban Kenya. Beeson JG, editor. PLoS ONE. 2011;6: e16085. doi:10.1371/journal.pone.0016085

27. Mikkelsen et al. - 2015 - A global assessment of civil registration and vita.pdf.

28. Turin DR. Health Care Utilization in the Kenyan Health System: Challenges and Opportunities. : 7.

29. How can precision mapping save children's lives? In: Healthdata.org [Internet]. [cited 10 May 2020]. Available: https://vizhub.healthdata.org/child-mortality

30. Levels and Trends in Child Mortality. In: UNICEF DATA [Internet]. 19 Sep 2019 [cited 27 Apr 2020]. Available: https://data.unicef.org/resources/levels-and-trends-in-child-mortality/

31. GHO | By category | Life tables by country - Kenya. In: WHO [Internet]. [cited 11 May 2020]. Available: https://apps.who.int/gho/data/view.main.60850?lang=en

32. Is mortality among under-five.

33. Kimani-Murage EW, Fotso JC, Egondi T, Abuya B, Elungata P, Ziraba AK, et al. Trends in childhood mortality in Kenya: The urban advantage has seemingly been wiped out. Health & Place. 2014;29: 95–103. doi:10.1016/j.healthplace.2014.06.003

34. Mutisya M, Orindi B, Emina J, Zulu E, Ye Y. Is mortality among under-five children in Nairobi slums seasonal? Tropical Medicine & International Health. 2010;15: 132–139. doi:10.1111/j.1365-3156.2009.02419.x

35. Beguy D, Elung'ata P, Mberu B, Oduor C, Wamukoya M, Nganyi B, et al. Health & Demographic Surveillance System Profile: The Nairobi Urban Health and Demographic Surveillance System (NUHDSS). International Journal of Epidemiology. 2015;44: 462–471. doi:10.1093/ije/dyu251

36. United Nations. World Mortality 2019: Data Booklet. UN; 2019. doi:10.18356/f6cceefe-en

37. Streatfield PK, Khan WA, Bhuiya A, Alam N, Sié A, Soura AB, et al. Cause-specific mortality in Africa and Asia: evidence from INDEPTH health and demographic surveillance system sites. Global Health Action. 2014;7: 25362. doi:10.3402/gha.v7.25362

38. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the

Sustainable Development Goals. The Lancet. 2016;388: 3027–3035. doi:10.1016/S0140-6736(16)31593-8

39. Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018;392: 1736–1788. doi:10.1016/S0140-6736(18)32203-7

40. Kyobutungi C, Ziraba AK, Ezeh A, Yé Y. The burden of disease profile of residents of Nairobi's slums: Results from a Demographic Surveillance System. Popul Health Metrics. 2008;6: 1. doi:10.1186/1478-7954-6-1

41. GBD Compare | IHME Viz Hub. [cited 10 May 2020]. Available: http://vizhub.healthdata.org/gbd-compare

42. Torre LA, Siegel RL, Ward EM, Jemal A. Global Cancer Incidence and Mortality Rates and Trends--An Update. Cancer Epidemiology Biomarkers & Prevention. 2016;25: 16–27. doi:10.1158/1055-9965.EPI-15-0578

43. Melaku YA, Sahle BW, Tesfay FH, Bezabih AM, Aregay A, Abera SF, et al. Causes of Death among Adults in Northern Ethiopia: Evidence from Verbal Autopsy Data in Health and Demographic Surveillance System. Helleringer S, editor. PLoS ONE. 2014;9: e106781. doi:10.1371/journal.pone.0106781

44. Rathod SD, Timæus IM, Banda R, Thankian K, Chilengi R, Banda A, et al. Premature adult mortality in urban Zambia: a repeated population-based cross-sectional study. BMJ Open. 2016;6: e010801. doi:10.1136/bmjopen-2015-010801

45. Mberu B, Wamukoya M, Oti S, Kyobutungi C. Trends in Causes of Adult Deaths among the Urban Poor: Evidence from Nairobi Urban Health and Demographic Surveillance System, 2003–2012. : 24.

46. Njuguna HN, Montgomery JM, Cosmas L, Wamola N, Oundo JO, Desai M, et al. Malaria Parasitemia Among Febrile Patients Seeking Clinical Care at an Outpatient Health Facility in an Urban Informal Settlement Area in Nairobi, Kenya. The American Journal of Tropical Medicine and Hygiene. 2016;94: 122–127. doi:10.4269/ajtmh.15-0293

47. Muhula S, Memiah P, Mbau L, Oruko H, Baker B, Ikiara G, et al. Uptake and linkage into care over one year of providing HIV testing and counselling through community and health facility testing modalities in urban informal settlement of Kibera, Nairobi Kenya. BMC Public Health. 2016;16: 373. doi:10.1186/s12889-016-3033-x

48. Byass P, Chandramohan D, Clark SJ, D'Ambruoso L, Fottrell E, Graham WJ, et al. Strengthening standardised interpretation of verbal autopsy data: the new InterVA-4 tool. Global Health Action. 2012;5: 19281. doi:10.3402/gha.v5i0.19281

49. Bauni E, Ndila C, Mochamah G, Nyutu G, Matata L, Ondieki C, et al. Validating physician-certified verbal autopsy and probabilistic modeling (InterVA) approaches to verbal autopsy interpretation using hospital causes of adult deaths. Popul Health Metrics. 2011;9: 49. doi:10.1186/1478-7954-9-49

50. Byass P, Fottrell E, Dao Lan Huong, Berhane Y, Corrah T, Kahn K, et al. Refining a probabilistic model for interpreting verbal autopsy data. Scand J Public Health. 2006;34: 26–31. doi:10.1080/14034940510032202

51. Olack B, Feikin DR, Cosmas LO, Odero KO, Okoth GO, Montgomery JM, et al. Mortality Trends Observed in Population-Based Surveillance of an Urban Slum Settlement, Kibera, Kenya, 2007–2010. PLOS ONE. 2014;9: 6.

52. Checkley W, Pollard SL, Siddharthan T, Babu GR, Thakur M, Miele CH, et al. Managing threats to respiratory health in urban slums. The Lancet Respiratory Medicine. 2016;4: 852–854. doi:10.1016/S2213-2600(16)30245-4

53. Admin A. Population and Health Dynamics in Nairobi's Informal Settlements: Report of the Nairobi Cross-sectional Slums Survey (NCSS) 2012. In: APHRC [Internet]. [cited 3 Jun 2020]. Available: https://aphrc.org/publication/population-and-health-dynamics-in-nairobis-informal-settlements-report-of-the-nairobi-cross-sectional-slums-survey-ncss-2012-3/

54. Hammitt LL, Etyang AO, Morpeth SC, Ojal J, Mutuku A, Mturi N, et al. Effect of ten-valent pneumococcal conjugate vaccine on invasive pneumococcal disease and nasopharyngeal carriage in Kenya: a longitudinal surveillance study. The Lancet. 2019;393: 2146–2154. doi:10.1016/S0140-6736(18)33005-8

55. MMed MS. Effect of 10-valent pneumococcal conjugate vaccine on the incidence of radiologically-confirmed pneumonia and clinically-defined pneumonia in Kenyan children: an interrupted time-series analysis. 2019;7: 10.

56. Bigogo GM, Audi A, Auko J, Aol GO, Ochieng BJ, Odiembo H, et al. Indirect effects of 10-valent pneumococcal conjugate vaccine against adult pneumococcal pneumonia in rural western Kenya. Clin Infect Dis. 2019;69: 2177–2184. doi:10.1093/cid/ciz139

57. Verguet S, Norheim OF, Olson ZD, Yamey G, Jamison DT. Annual rates of decline in child, maternal, HIV, and tuberculosis mortality across 109 countries of low and middle income from 1990 to 2013: an assessment of the feasibility of post-2015 goals. The Lancet Global Health. 2014;2: e698–e709. doi:10.1016/S2214-109X(14)70316-X

58. Kebede Y, Andargie G, Gebeyehu A, Awoke T, Yitayal M, Mekonnen S, et al. Tuberculosis and HIV are the leading causes of adult death in northwest Ethiopia: evidence from verbal autopsy data of Dabat health and demographic surveillance system, 2007–2013. Popul Health Metrics. 2017;15: 27. doi:10.1186/s12963-017-0139-z

59. HIV estimates report-Kenya-2018.

60. Noykhovich E, Mookherji S, Roess A. The Risk of Tuberculosis among Populations Living in Slum Settings: a Systematic Review and Meta-analysis. J Urban Health. 2019;96: 262–275. doi:10.1007/s11524-018-0319-6

61. J. Madise N, Ziraba AK, Inungu J, Khamadi SA, Ezeh A, Zulu EM, et al. Are slum dwellers at heightened risk of HIV infection than other urban residents? Evidence from population-based HIV prevalence surveys in Kenya. Health Place. 2012;18: 1144–1152. doi:10.1016/j.healthplace.2012.04.003

62. Greif MJ, Dodoo FN-A, Jayaraman A. Urbanisation, Poverty and Sexual Behaviour: The Tale of Five African Cities. Urban Studies. 2011;48: 947–957. doi:10.1177/0042098010368575

63. National_Malaria_Strategy_2009-2017.

64. Martens P, Hall L. Malaria on the move: human population movement and malaria transmission. Emerg Infect Dis. 2000;6: 103–109.

65. Gouda HN, Charlson F, Sorsdahl K, Ahmadzada S, Ferrari AJ, Erskine H, et al. Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017. The Lancet Global Health. 2019;7: e1375–e1387. doi:10.1016/S2214-109X(19)30374-2

66. Juma K, Juma P, Shumba C, Otieno P, Asiki G. Non-Communicable Diseases and Urbanization in African Cities: A Narrative Review. Public Health in Developing Countries - Challenges and Opportunities. 2019 [cited 30 Jul 2020]. doi:10.5772/intechopen.89507

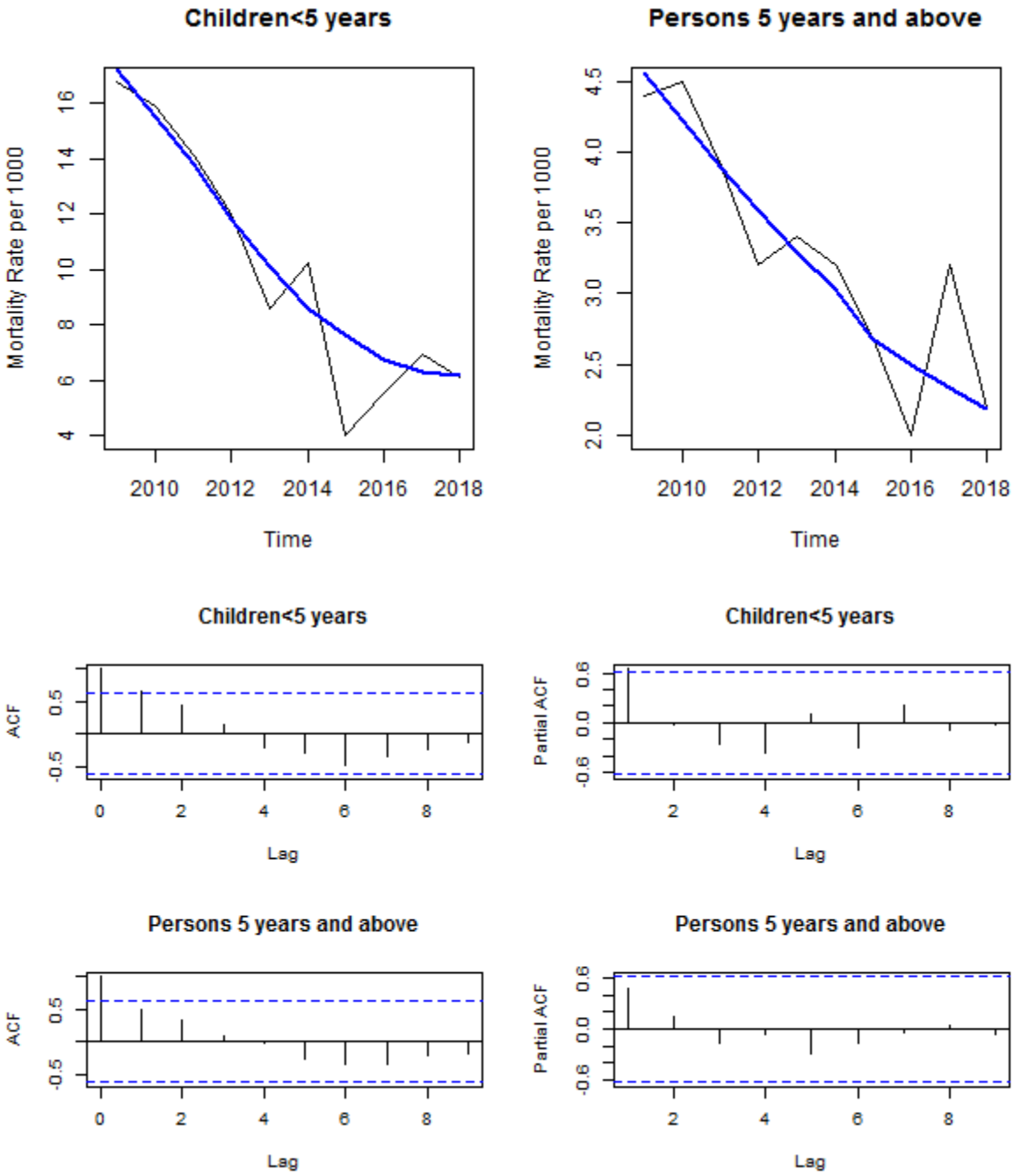
67. Ettarh R, Van de Vijver S, Oti S, Kyobutungi C. Overweight, Obesity, and Perception of Body Image Among Slum Residents in Nairobi, Kenya, 2008–2009. Prev Chronic Dis. 2013;10: 130198. doi:10.5888/pcd10.130198

68. Fottrell E, Byass P. Verbal Autopsy: Methods in Transition. Epidemiologic Reviews. 2010;32: 38–55. doi:10.1093/epirev/mxq003

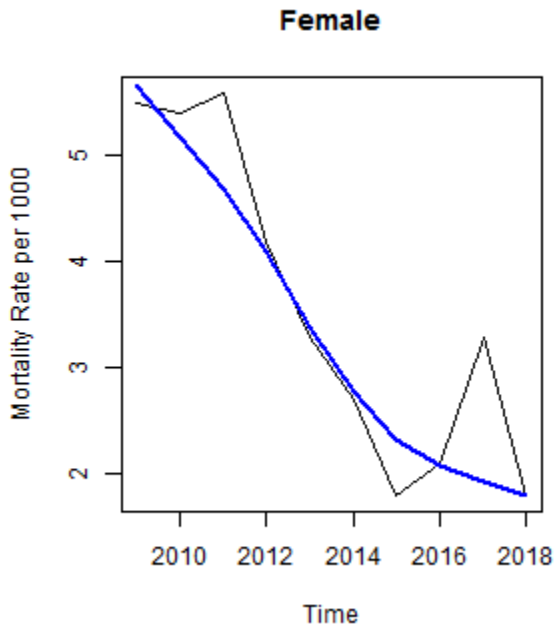
6.0 APPENDIX

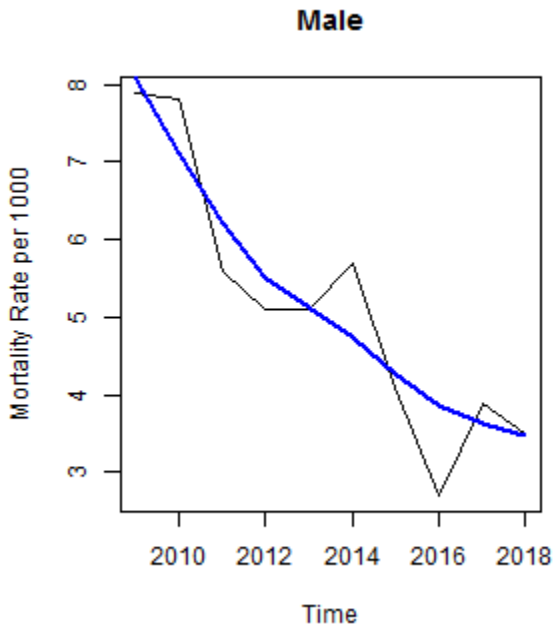
6.1 ACF and PACF plots

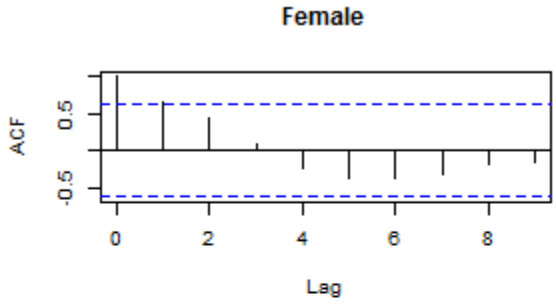
6.1.1Mortality rates by age group, ACF and PACF plot

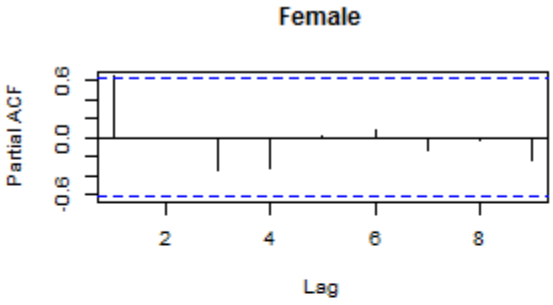


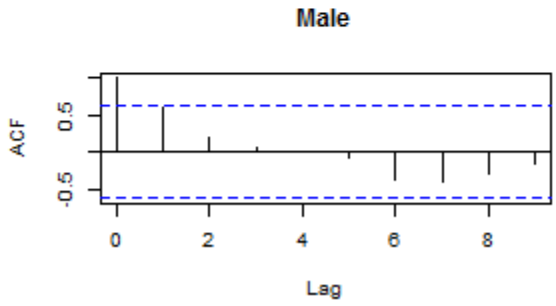
6.1.2 Mortality rates by sex, ACF and PACF plot

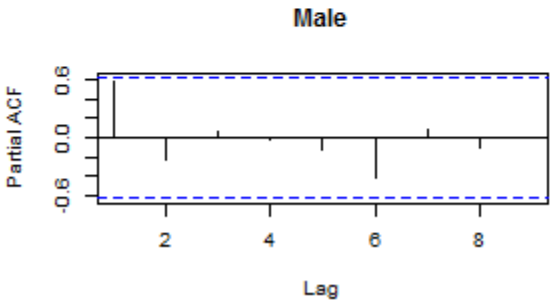




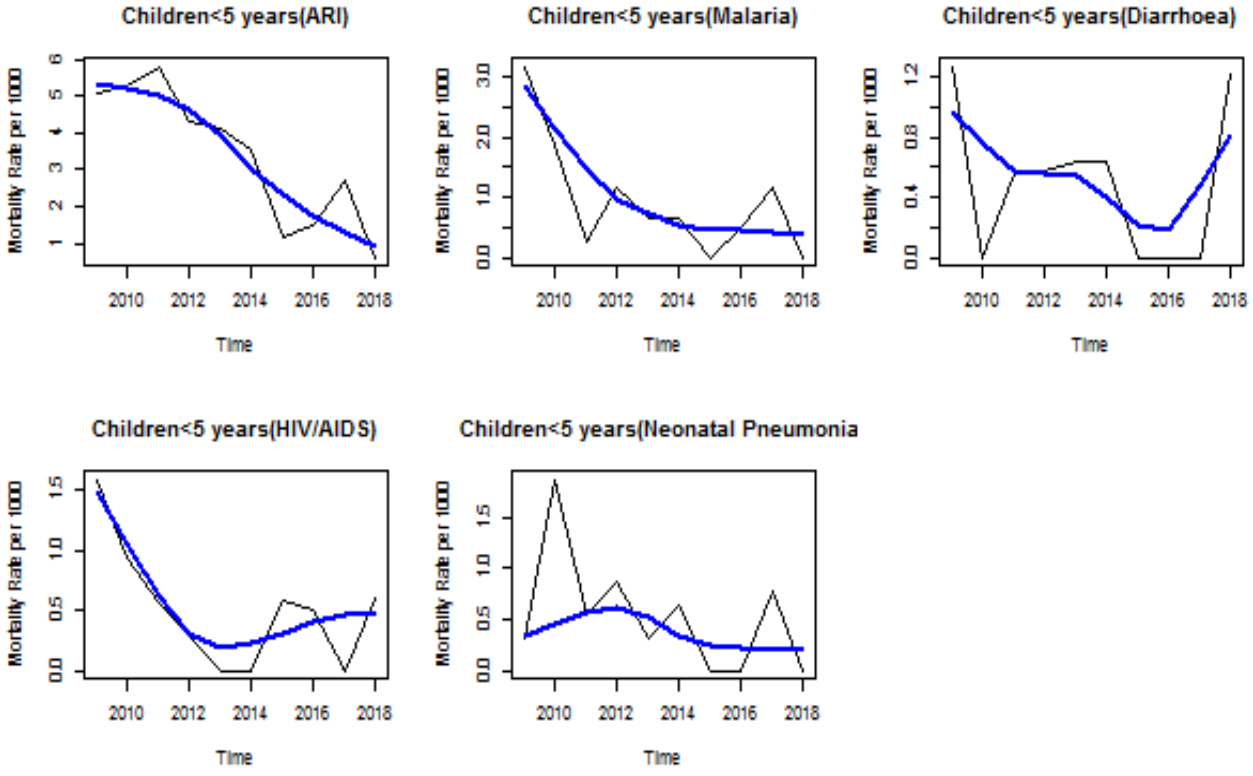


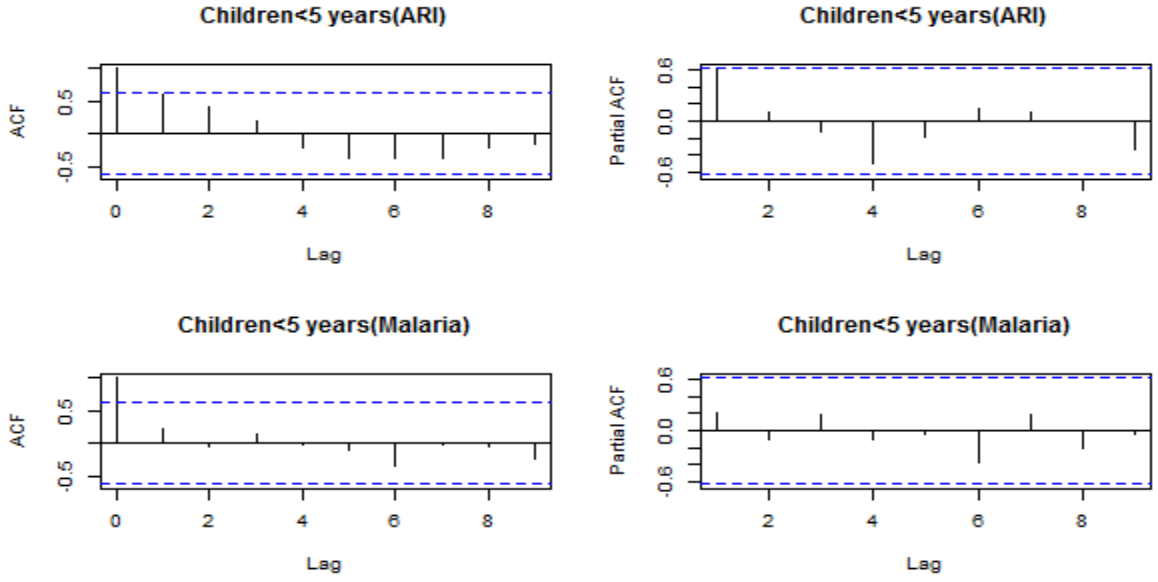


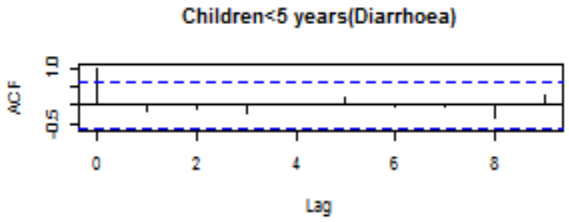


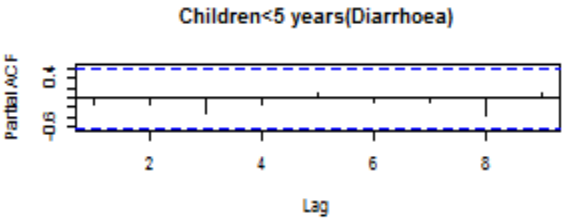


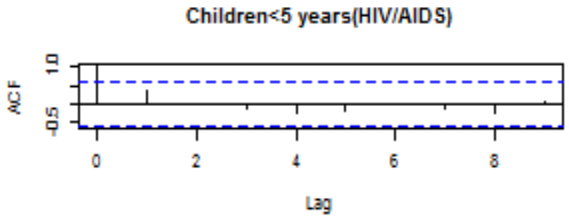
6.1.3 Mortality rates by Generalised Cause of death, ACF and PACF plot

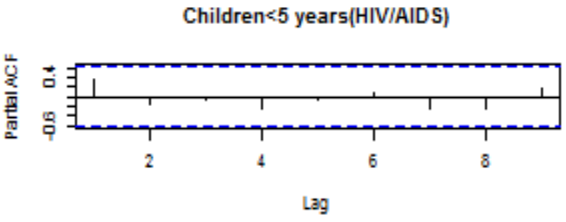


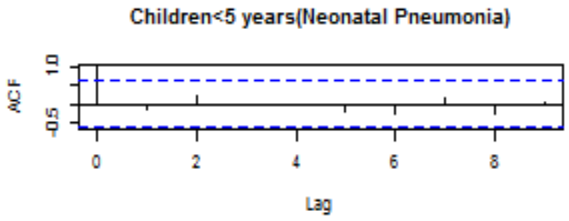


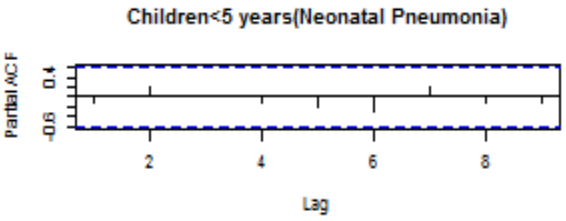

Children<5 years(Diarrhoea)
ACF
1.0
0.5
0
2
4
6
8
Lag

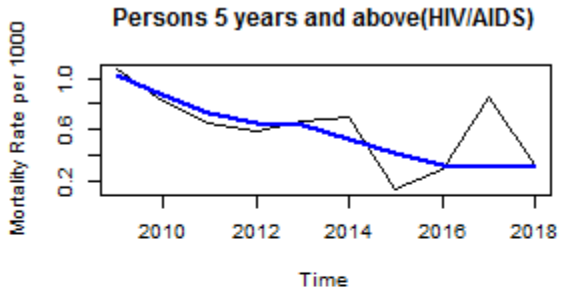

Children<5 years(Diarrhoea)
Partial ACF
0.4
-0.6
2
4
6
8
Lag

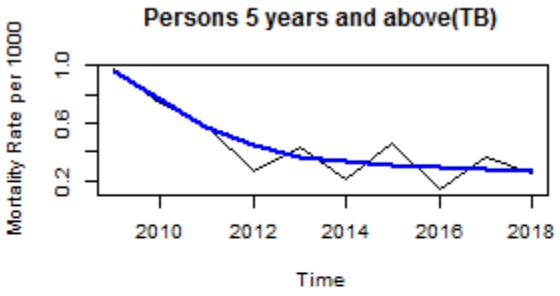

Children<5 years(HIV/AIDS)
ACF
1.0
0.5
0
2
4
6
8
Lag

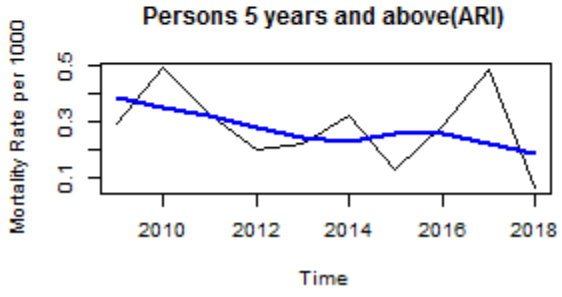

Children<5 years(HIV/AIDS)
Partial ACF
0.4
-0.6
2
4
6
8
Lag

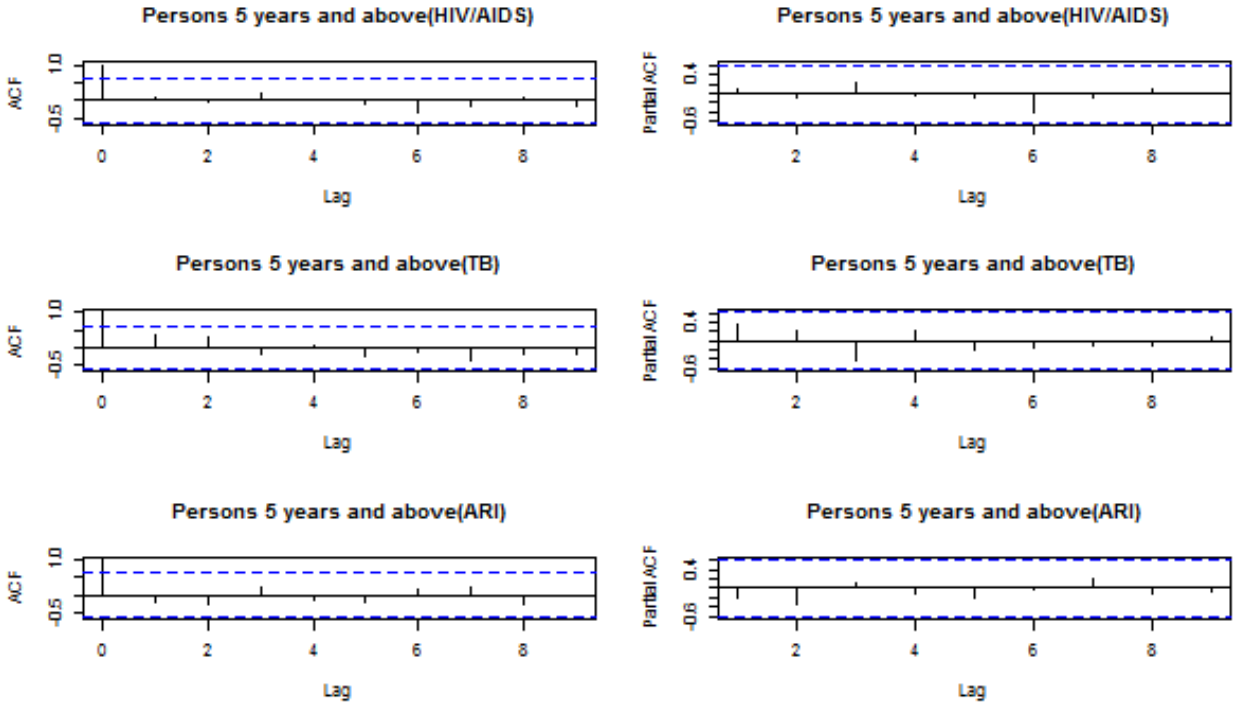

Children<5 years(Neonatal Pneumonia)
ACF
1.0
0.5
0
2
4
6
8
Lag


Children<5 years(Neonatal Pneumonia)
Partial ACF
0.4
-0.6
2
4
6
8
Lag

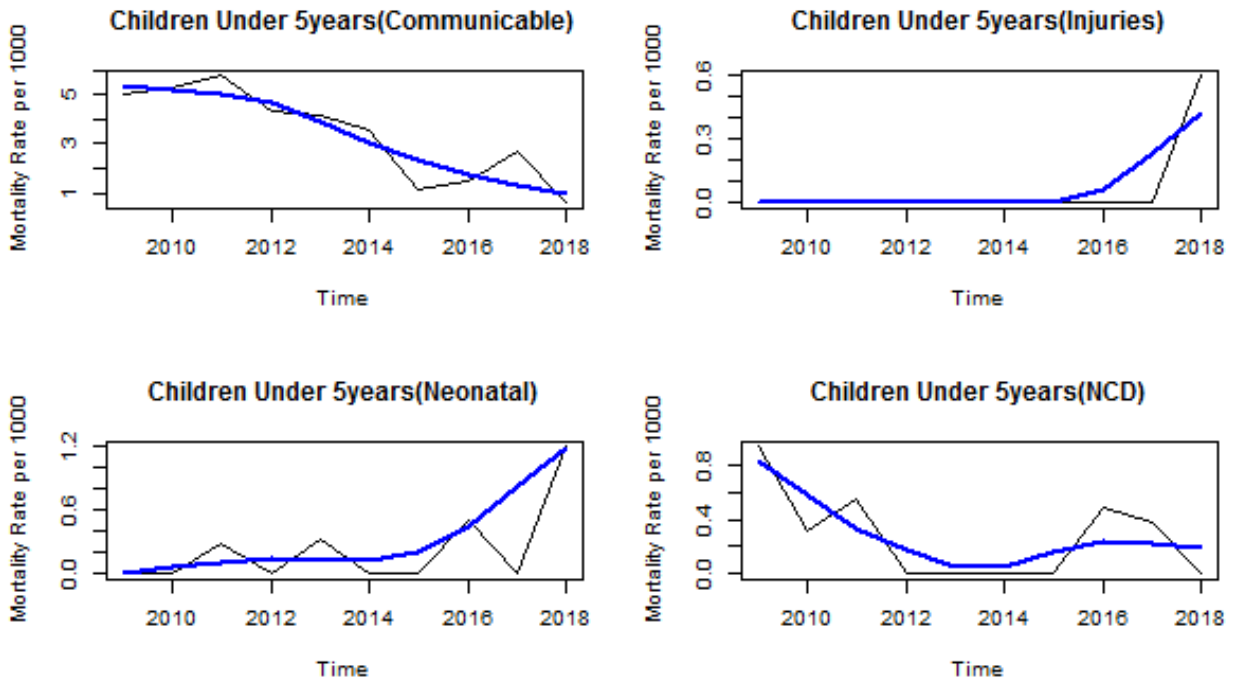

Persons 5 years and above(HIV/AIDS)
Mortality Rate per 1000
0.2
0.6
1.0
2010
2012
2014
2016
2018
Time

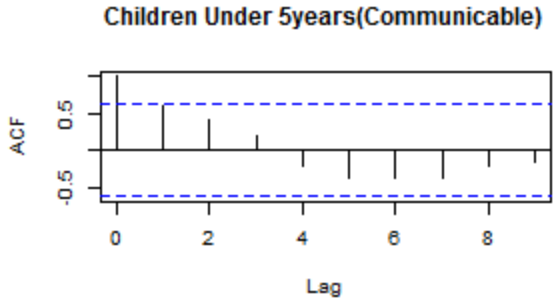

Persons 5 years and above(TB)
Mortality Rate per 1000
0.2
0.6
1.0
2010
2012
2014
2016
2018
Time

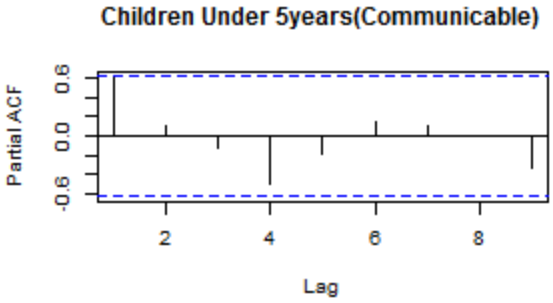

Persons 5 years and above(ARI)
Mortality Rate per 1000
0.1
0.3
0.5
2010
2012
2014
2016
2018
Time

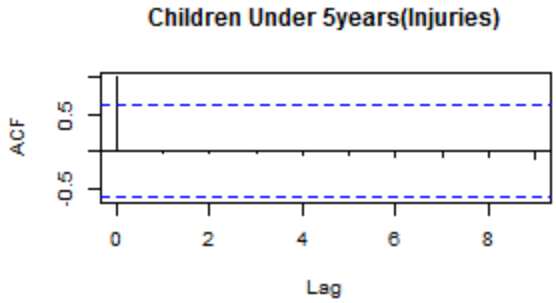


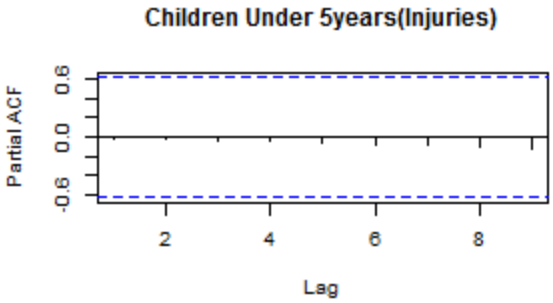
6.1.4 Mortality rates by grouped cause of death, ACF and PACF plot

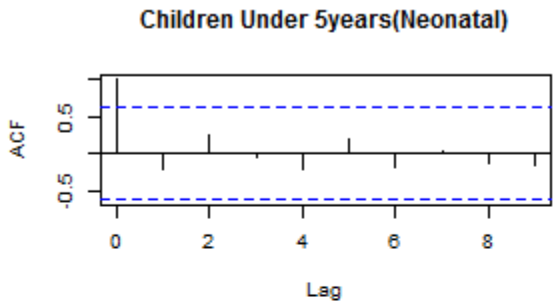


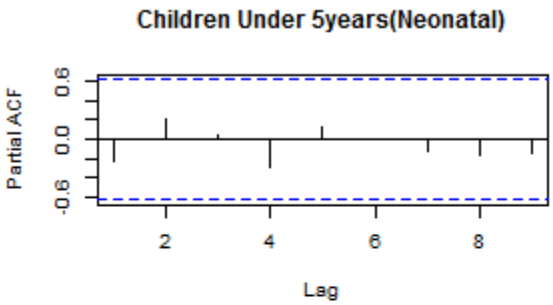

Children Under 5years(Communicable)
ACF
0.5
-0.5
0
2
4
6
8
Lag

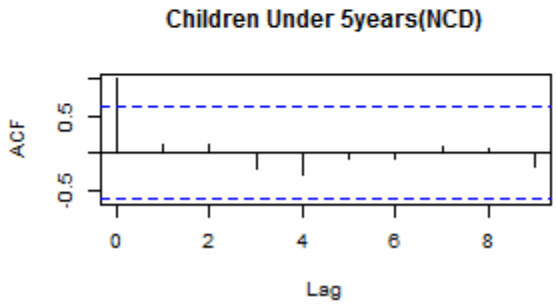

Children Under 5years(Communicable)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag

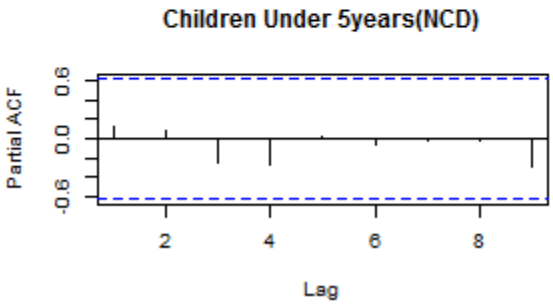

Children Under 5years(Injuries)
ACF
0.5
-0.5
0
2
4
6
8
Lag

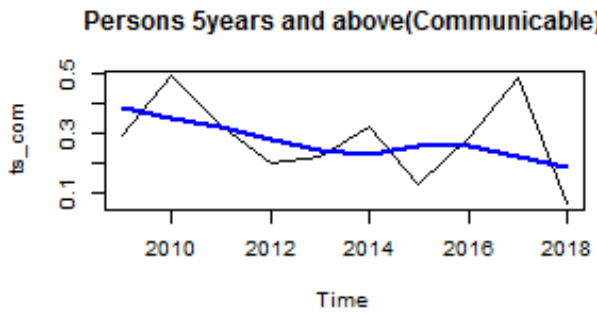

Children Under 5years(Injuries)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag

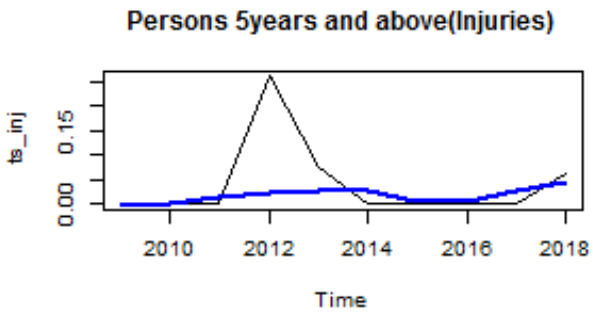

Children Under 5years(Neonatal)
ACF
0.5
-0.5
0
2
4
6
8
Lag

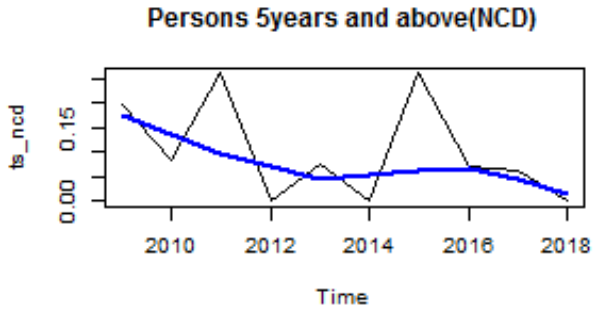

Children Under 5years(Neonatal)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag

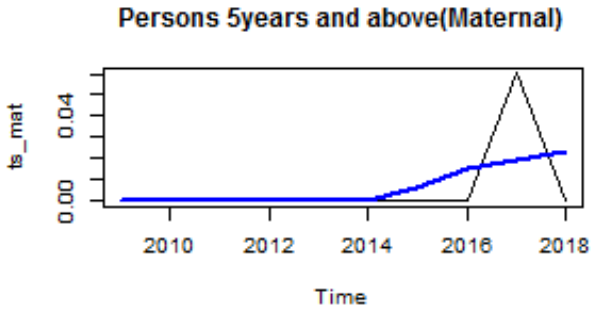

Children Under 5years(NCD)
ACF
0.5
-0.5
0
2
4
6
8
Lag

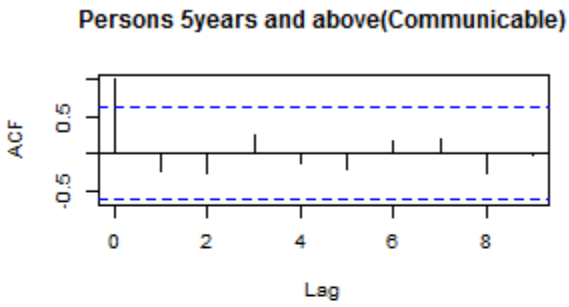

Children Under 5years(NCD)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag

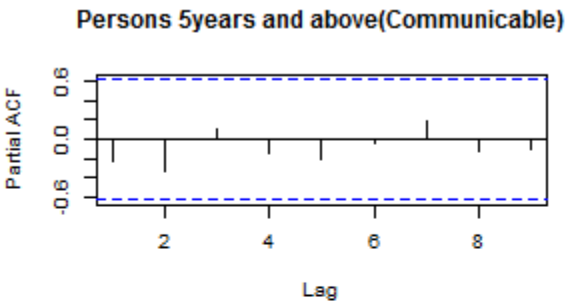

Persons 5years and above(Communicable)
ts_com
0.1
0.3
0.5
2010
2012
2014
2016
2018
Time

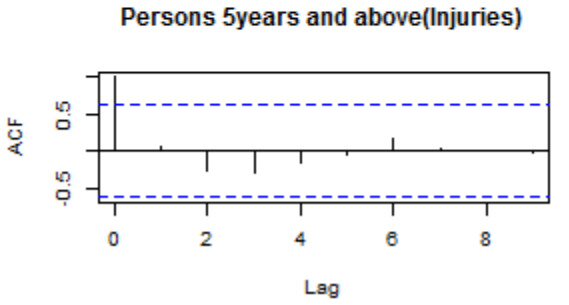

Persons 5years and above(Injuries)
ts_inj
0.00
0.15
2010
2012
2014
2016
2018
Time

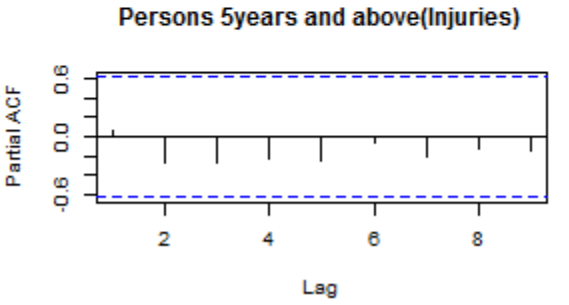

Persons 5years and above(NCD)
ts_ncd
0.00
0.15
2010
2012
2014
2016
2018
Time

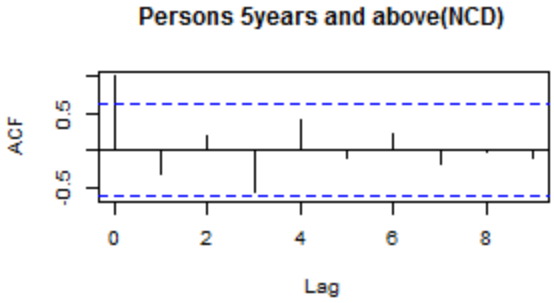

Persons 5years and above(Maternal)
ts_mat
0.00
0.04
2010
2012
2014
2016
2018
Time

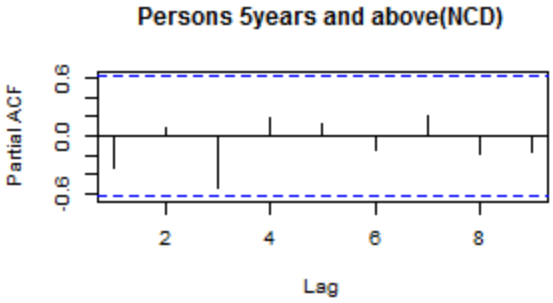

Persons 5years and above(Communicable)
ACF
-0.5
0.5
0
2
4
6
8
Lag

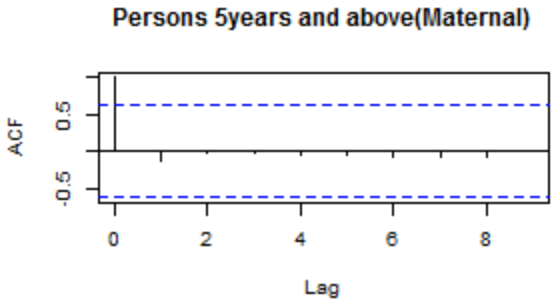

Persons 5years and above(Communicable)
Partial ACF
-0.6
0.0
0.6
2
4
6
8
Lag

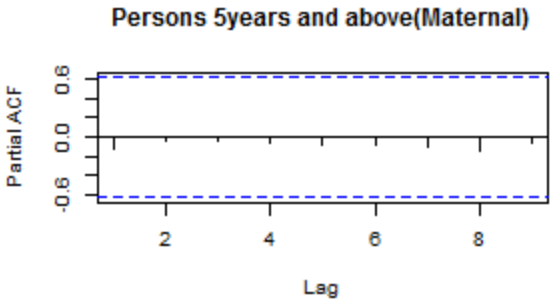

Persons 5years and above(Injuries)
ACF
-0.5
0.5
0
2
4
6
8
Lag


Persons 5years and above(Injuries)
Partial ACF
-0.6
0.0
0.6
2
4
6
8
Lag


Persons 5years and above(NCD)
ACF
0.5
-0.5
0
2
4
6
8
Lag

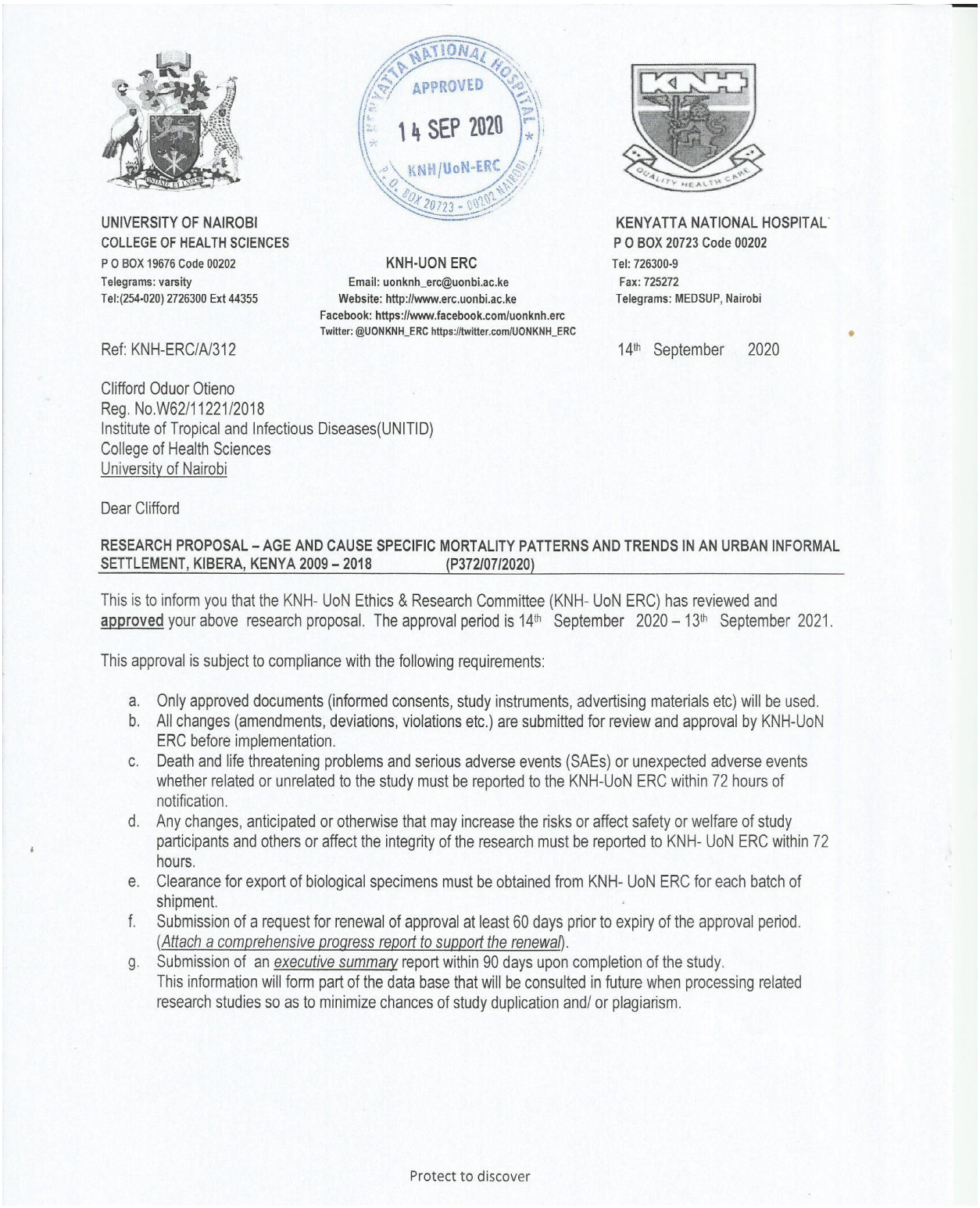

Persons 5years and above(NCD)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag


Persons 5years and above(Maternal)
ACF
0.5
-0.5
0
2
4
6
8
Lag


Persons 5years and above(Maternal)
Partial ACF
0.6
0.0
-0.6
2
4
6
8
Lag

7.0 APPENDIX

7.1 ERC approval



KENYATTA NATIONAL HOSPITAL
APPROVED
14 SEP 2020
KNH/UoN-ERC
P. O. BOX 20723 - 00202 NAIROBI

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/312

14th September 2020

Clifford Oduor Otieno
Reg. No.W62/11221/2018
Institute of Tropical and Infectious Diseases(UNITID)
College of Health Sciences
University of Nairobi

Dear Clifford

RESEARCH PROPOSAL – AGE AND CAUSE SPECIFIC MORTALITY PATTERNS AND TRENDS IN AN URBAN INFORMAL SETTLEMENT, KIBERA, KENYA 2009 – 2018 (P372/07/2020)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 14th September 2020 – 13th September 2021.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

Protect to discover

For more details consult the KNH- UoN ERC website**http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Director, UNITID, UoN
Supervisors: Dr. George O.Agogo(CDC-Kenya), Dr. Peter Nguhiu(UNITID, UoN)