



Uppsala University – Medical faculty
Department of Women's and Children's Health
International Maternal and Child Health (IMCH)

Degree project, 30 ECTS
Master of Medical Science in International Health
Spring 2015

Seasonal variations in under-five mortality,
stratified by neonatal, post-neonatal and child mortality,
in Korogocho and Viwandani urban slums in Nairobi, Kenya
– a time-series analysis on secondary data from
the Nairobi Urban Health and Demographic Surveillance System (NUHDSS)

Word Count: 12,089

Marianna Moberg

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Abstract

Background Globally, the amount of people living in urban poor settings is increasing rapidly. In order to effectively direct resources and achieve equity in health, an understanding of how contextual factors are affecting mortality in marginalised groups is first needed.

Aim This study aims at clarifying if seasonality can be associated with mortality in different child age spans i.e. neonatal, post-neonatal and children under five in two urban slum settlements in Nairobi, Kenya.

Methodology Secondary seasonal mortality data from the Nairobi Urban Health and Demographic Surveillance System (NUHDSS), collected in the years 2008–2010 in Viwandani and Korogocho slums in Nairobi, Kenya was decomposed into seasonal components with a moving average comparison. Seasonal indices were created on disaggregated data for the different mortality groups and gender strata.

Results The annual mean prevalence of under-five mortality [U5M] and neonatal mortality [NM] was 86 and 20 respectively. Overall U5M increased from April–August. Post-neonatal mortality [PM] had the earliest onset (April–May) followed by NM (May–August). Child mortality [CM] had two peaks, June–August and November.

Conclusion The displayed seasonal pattern in NM, PM, CM and U5M seemingly corresponded to the yearly fluctuation of temperature and precipitation, with a predominant intensification in the wettest and coldest months. CM seemed to be the only group with increased mortality also in the second rain period, not reflected in the overall mortality index. These findings could be used to set the agenda for preventative interventions aimed at reducing childhood mortality and morbidity.

Key words Seasonality, seasonal index, under-five, neonatal, post-neonatal, mortality, slums, Nairobi, NUHDSS, Korogocho, Viwandani

Abbreviations

APHRC	African Population and Health Research Centre
ANC	Antenatal care
CM	Child mortality
DHS	Demographic health survey
HIC	High-income countries
IM	Infant mortality
KEMRI	Kenya Medical Research Institute
KMD	Kenya Meteorological Department
KENSUP	Kenya Slum Upgrading Programme
LIC	Low-income countries
LMIC	Low- and middle-income countries
MA	Moving average
MDG	Millennium development goal
NUHDSS	Nairobi Urban Health and Demographic Surveillance System
NM	Neonatal mortality
PM	Post-neonatal mortality
SA	South Asia
SSA	Sub-Saharan Africa
U5M	Under-five mortality
UN-Habitat	United Nations Human Settlements Programme
UNICEF	United Nations Children's Fund
WASH	Water, sanitation and hygiene
WMO	World Meteorological Organization
WHO	The World Health Organization

Definitions

Definitions of child mortality

<u>Definition</u>	<u>Deaths that occur:</u>
Neonatal mortality	Between birth, before reaching 28 days of age
Post-neonatal mortality	Between 1 month and exact 1 year of age
Infant mortality	Between birth and exact 1 year of age
Child mortality	Between 1 year and exact 5 years of age
Under-five mortality	Between birth and exact 5 years of age

(UNICEF et al., 2007, p. 9)

Slum definition

“... a contiguous settlement where the inhabitants are characterized as having inadequate housing and basic services. A slum is often not recognised and addressed by the public authorities as an integral or equal part of the city.” (UN-Habitat and Global Urban Observatory, 2003, p. 6).

A slum household lacks **one or more** of the below listed components:

<u>Component:</u>	<u>Definition:</u>
Access to safe water	“... sufficient amount of water for family use, at an affordable price ...”
Access to sanitation	“... excreta disposal system, either in the form of a private toilet or a public toilet shared with a reasonable number of people ...”
Secure tenure	“... effective protection by the State against forced evictions ...”
Durability of housing	“... built on a non-hazardous location ... adequate enough to protect its inhabitants from the extremes of climatic conditions ...”
Sufficient living areas	“... not more than two people share the same room.”

(UN-Habitat and Global Urban Observatory, 2003, p. 7).

1. Introduction

1.1. Mortality in young children

Under-five mortality [U5M] rate, i.e. children dying before their fifth birthday per 1,000 live births, has been said to be a key indicator of child well-being in a country, as well as an indicator for the coverage of child survival interventions, thus reflecting a country's social and economical development (UNICEF et al., 2014). In low-income countries [LIC] in 2013, the averaged U5M rate was estimated to be 76 per 1,000 live births, more than 12 times the U5M rate in high-income countries [HIC] (ibid.).

Globally, the leading causes of U5M in 2013 was pneumonia, diarrhoea, malaria and neonatal causes, e.g. intrapartum-related complications such as birth asphyxia and sepsis – all highly preventable and to a large extent attributable to undernutrition (UNICEF et al., 2014).

Nonetheless, since the formulation of the Millennium Development Goals [MDG] in 1990, the annual U5M has dropped from 12.6 million to 6.6 million in the 75 most affected countries, generally known as the 'Countdown countries' (Requejo et al., 2014).

Even if U5M has dropped in recent years, 6.3 million under-five deaths still occur in our world annually (UNICEF et al., 2014). Most annual child deaths occur in south Asia [SA] and sub-Saharan Africa [SSA], regardless if looking at total numbers or mortality rates (ibid.). Moreover, estimations by UNICEF et al. (2014) were that by 2050, 40 per cent of all births globally will take place in SSA region, which will also be the home to 37 per cent of all children under the age.

Intra-country differences of under-five survival can be alarmingly large (UNICEF, 2012). Most of the deaths occur in rural areas; nevertheless, slum populations tend to have exceptionally high under-five mortality rates, where unhygienic environments and lack of basic sanitation and clean water are mentioned as risk factors and contribute to about 90 per cent of all diarrhoeal deaths (Black et al., 2003; UNICEF, 2012).

Similarly, neonatal mortality [NM], i.e. children dying within the first 28 days after birth, has been strongly associated with poverty (Lawn et al., 2005). In 2013, NM accounted for 44 per cent

of all U5M globally and in the SSA-region the corresponding proportion was 34 per cent, with the trend of an increasing quantity in all WHO regions, indicating better survival in older ages (UNICEF et al., 2014). Neonatal deaths occur primarily as a consequence of lack of access to effective maternal health care services and inadequate health care seeking behaviour leading to e.g. prolonged labour and birth asphyxia. Most of NM take place within the first week of life, i.e. during the early neonatal period, with the vast majority during labour, thus making maternal health an important determinant for neonatal survival (Lawn et al., 2005).

1.2. Urbanisation

Children in urban areas are in general better off than children living in rural areas due to higher standards of health, education and sanitation. These and other attractors, such as employment, tend to draw people to move to the cities (UNICEF, 2012).

Globally, the urban population has gone from 20 per cent a century ago, to outnumbering the rural population at the beginning of this century (UN-Habitat and World Urban Forum, 2012). Estimations are that by 2050, 70 per cent of the planet's population will reside in cities and the most rapid urbanisation will be seen in the low- and middle-income countries [LMIC], where the urban population increases with approximately 200,000 persons daily (ibid.).

Rural-to-urban migration is the most common in LMIC, resembling the migration that occurred during the industrial revolution in 18th and 19th century Europe (UN-Habitat and World Urban Forum, 2012). However, many LMIC lack governance and adequate economic growth to support this in-migration, thus slums arise as a consequence of poor people needing accessible and affordable housing, not provided elsewhere (ibid.). Recent estimates state that by 2025 the African region will have the most populous urban areas in the world, with 642 million living in cities. Paradoxically, the African region will still be the least urbanised globally, with 45 per cent of its population living in cities (ibid.). In the Americas and Europe 80 per cent of the populations live in cities. Here, the rural-to-urban migration has declined, nonetheless still being substantial. Instead, international migrants account for the most marginalized groups, and are at risk for slum formations (ibid.).

1.2.1. Urban slums

In 2009, 46 per cent of the urban populations in LMIC were living in slums, and in SSA these figures were estimated to be as high as 38 per cent, accounting for 345 million inhabitants.

However, when looking at absolute numbers, SA has the most slum dwellers with 574 million or approximately 32 per cent of the world's slum inhabitants (UN-Habitat and World Urban Forum, 2012).

However, there is no universally agreed upon a definition of what a 'slum' is and countries decide for themselves what to call a slum. In a report from UN-Habitat (2003) 29 cities were included in a case study comparing definitions of the existence of a slum population as stated by the city governments. The definitions used varied widely, and out of the cities studied, eight lacked a formal definition and the cities that had a definition the content varied widely. The most commonly used criteria to define a slum area were: bad construction of housing (60 per cent), lack of legal status (55 per cent) and lack of basic service (45 per cent), e.g. water, sanitation and electricity. Five of the cities mentioned poverty as part of their slum definition (ibid.).

Target 11 of MDG 7 (Ensure environmental sustainability) is to "achieve significant improvement in lives of at least 100 million slum dwellers, by 2020." (UN-Habitat and Global Urban Observatory, 2003, p. 2). In this thesis, *slums* will refer to the definitions developed by UN-Habitat and Global Urban Observatory (2003), to enable monitoring of target 11. They have concluded that a slum household is to be defined as one living under conditions lacking one or more of the following five key dimensions: access to safe water, access to sanitation, secure tenure, durability of housing or sufficient living areas (ibid.). These definitions were designated during an expert group meeting held in Nairobi, Kenya (ibid.).

1.2.2. Urban, rural and intra-urban differences in health

Urban slums are a physical manifestation of rapid urbanisation and intra-urban inequalities (UN-Habitat, 2003). Still, slum inhabitants are not a homogenous groups, e.g. not everyone living in slums are poor, and not all poor people in the city live in the slums. Nonetheless, a paradigm shift is evident, where poverty and undernutrition is increasing in cities globally (ibid.). UN-Habitat and World Urban Forum (2012) stress that equity in e.g. income distribution and socio-economic

benefits in a society, is crucial in order to achieve a prosperous city and a sustainable economic growth.

Fotso (2006) studied the intra-urban inequalities regarding different health outcomes by researching demographic health survey [DHS] data from fifteen SSA countries. The main findings were that the intra-urban differences in child malnutrition and stunting were significantly larger compared to urban-rural disparities. Ernst et al. (2013) made similar findings when comparing rural, urban and slum children and different health indicators, such as mortality and stunting, in several countries. These findings support the statement by Unger (2013) and UNICEF (2012), who stress that to enable promotion of equity in health across socio-economic groups, a situation analysis of disaggregated intra-urban information needs to be compiled. However, these data are rare (Unger, 2013).

Fry et al. (2002) investigated the health status of children living in slums in three rapidly expanding cities: Manila, Ahmedabad and Cairo. They found that these children had a higher prevalence of respiratory infections and diarrhoeal diseases and that post-neonatal and child mortality in these areas were higher than in rural areas. Matching these results are findings in the Nairobi context where Kimani-Murage et al. (2014) found that the total U5M in Kenya had declined over the last thirty years and that the urban-rural gap in infant mortality [IM] and child mortality [CM] had narrowed and even turned to favour the rural children. Since 2002, when the first measures were made, IM and U5M had decreased also in the slums (*ibid.*). Yet, in comparison, urban slums had a higher average of registered deaths: the U5M rate was 104 per 1,000 live births in slums as compared to 75, 72.5 and 73 for the urban as a whole, rural and Kenya as a whole, respectively. The IM rate was 75 per 1,000 live births in the slum areas as compared to 65, 56 and 58 for the urban as whole, rural and Kenya as a whole, respectively (*ibid.*).

1.3. Seasonality and mortality

Seasonal changes are defined as highly predictable cyclic events (Altizer et al., 2006) and seasonal patterns in e.g. mortality rates are a scrutinized and well-known phenomena in most regions worldwide. In some regions and groups, mortality increases during the hottest season,

whilst in others during the wet and cold season. People of older age and children are seemingly the most susceptible to seasonal variations (Becker and Weng, 1998; Burkart et al., 2011; Engelaer et al., 2014).

Findings in LIC suggest a correlation between the annual peaks of rainy and cold weather and increased U5M, often related to infectious diseases, e.g. malaria (Rumisha et al., 2013), diarrhoeal disease (Burkart et al., 2011) and pneumonia (Ye et al., 2009). Altizer et al. (2006) systematically reviewed articles looking at the dynamics of infectious disease and seasonality. They found that there were multifactorial seasonal reasons to why diseases to spread in societies. For example, changes in human social behaviours, e.g. calendar events such as school terms and holidays where families tend to spend time together, seemingly increased the transmission incidence (ibid.). Seasonal changes in weather were also mentioned influencing the spread of infectious diseases, e.g. seasonal rainfall in warmer regions might increase the transmission of vector borne diseases, such as dengue and malaria. Some vectors, e.g. malaria and helminth larvae, are dependent on a humid environment to evolve and some diseases, such as Ebola, seem to peak just after a rainy period (ibid.).

Burkart et al. (2011) found that children in Bangladesh were prone to seasonal fluctuations in mortality, finding patterns corresponding to the onset of the yearly monsoon as well as the cold season. In rural areas of Tanzania and Ghana, research has shown that the annual rain and cold periods could be related to increased child mortality and also old age mortality (Engelaer et al., 2014; Rumisha et al., 2013). In Kenya, seasonality in U5M was found in a study by Mutisya et al. (2010) who analysed surveillance data over three years from Korogocho and Viwandani slums in Nairobi. They found that there was a peak in U5M in May–July, correlating with the onset of the rainy and cold period, increasing the risk of mortality with 56–60 per cent. Another interesting finding was the gender inequality in mortality, significantly favouring girl children (ibid.).

Seasonality was also found when looking at pneumonia prevalence and mortality among children in the Nairobi slum settlements (Ye et al., 2009). Findings were that pneumonia was the overall leading cause of death during the study period, accounting for 26 per cent of all deaths. April–

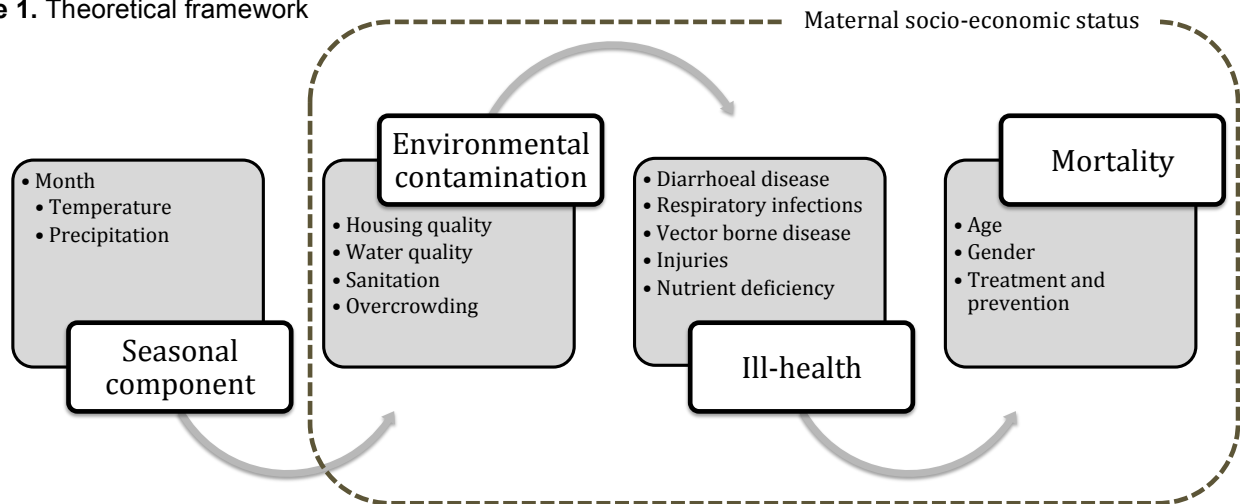
June was the peak period with a risk ratio of 2.3 and strongly associated with the annual wet and cold season (ibid.).

1.4. Theoretical framework

Victora et al. (1997) stress the advantages in using a conceptual model when designing and analysing studies of complex epidemiological nature. Many studied health outcomes e.g. child health in LIC, have factors that act through ‘inter-related proximate determinants,’ i.e. wealth or maternal educational level, with relations hard to assess without a logical framework (ibid.).

The theoretical framework applied in this thesis (**Figure 1**) was inspired by the *Framework for the Study of Child Survival* by Mosley and Chen (1984). The original framework demonstrates a causal mesh that integrates both social and medical determinants of child mortality. The authors argue that there are many interlinked factors leading to a child’s well being. The key determinants presented, deriving from the *socio-economic determinants*, are: *maternal factors*, *environmental contamination*, *nutrient deficiency* and *injury*. These are in turn affected by the *personal illness control* that determines whether *preventative measures* and/or *treatment* are attained.

Figure 1. Theoretical framework



In the applied framework (**Figure 1**) the original outcome variable *mortality/morbidity* was replaced by *mortality* alone, as mortality was in the study objective. The outcome (*mortality*) was considered to be predicted by a series of direct (*ill-health*) and indirect determinants (*environment*

contamination and *seasonal component*) with underlying factors. What was added to the modified framework, for the purpose of fitting this thesis, was the *seasonal component*, assumingly affecting the environmental element. Also, the *environmental contamination* variables were slightly rephrased to correspond to the applied slum-definition. The underlying determinants to *ill-health* were directly acquired from the original framework. Furthermore, the original definitions *maternal factors* and *socio-economic determinants* were merged and replaced by the definition *maternal socio-economic status*, permeating all other determinants. The motive for this was that socio-economic status, especially maternal education and wealth, is an established influential determinant on child health in the field of public health (Marmot, 2005).

1.5. Rationale

The amount of people living in urban poor settings is estimated to increase rapidly. Young children, especially those living in deprived settings such as urban slums, are a vulnerable population. In order to effectively direct resources and achieve equity in health, an understanding of how contextual factors are affecting mortality in marginalised groups is first needed. Limited studies have been conducted focusing on seasonality in Kenyan slums and no known research has previously scrutinised how mortality in different child mortality groups is seasonally varied.

1.5.1. Aim

This study aims at clarifying if seasonality can be associated with mortality in different child age spans in young children, i.e. neonates, post-neonatal and children under five years of age, in two urban slum settlements in Nairobi, Kenya by comparing seasonal surveillance data from the years 2008, 2009 and 2010.

1.5.2. Specific objectives

The specific objectives guiding this research has been:

1. To describe if there were seasonal variations in under-five mortality in Korogocho and Viwandani urban slums in Nairobi, Kenya in the years 2008 to 2010.
2. To stratify the under-five mortality data into defined mortality groups i.e. neonatal, post-neonatal and child mortality, to describe the seasonal variations separately.
3. To further describe the seasonal fluctuations of mortality, in the study population and period, by stratifying the mortality groups by gender.

2. Methodology

2.1. Study design

This thesis presents a time series analysis on U5M using secondary data on monthly mortality from the Nairobi Urban Health and Demographic Surveillance System [NUHDSS], collected in the years 2008–2010 in Viwandani and Korogocho slums in Nairobi, Kenya.

2.2. Study setting

2.2.1. Kenya

Kenya is a LIC and one of the Countdown countries. It is located in the east of SSA, neighbouring Ethiopia, Uganda, Tanzania, South Sudan and Somalia. In 2013 the population was 44 million and out of these 25 million were under the age of fifteen. Life expectancy for both females and males was 59 years. The under-five and infant mortality rate (per 1000 live births) was 71 and 33 respectively (The World Bank, 2014). In 2012 the main U5M-causes in Kenya were pneumonia (17 per cent), diarrhoea (10 per cent), injuries (6 per cent) and malaria (4 per cent). Neonatal causes accounted for 37 per cent of all U5M (Countdown to 2015, 2014).

The capital city Nairobi (**Figure 2**) is situated at an altitude of 1,700 metres above sea level, which makes the climate somewhat colder than in other tropical cities (Mutisya et al., 2010). The capital is estimated to be the home to 3.4 million inhabitants, covering an area of 684 square kilometres. This makes Nairobi the most populous city in east Africa (African Population and Health Research Center (APHRC), 2014; Google Maps, 2015a). Despite being an internationally established business centre, Nairobi has more than 100 slum settlements within the city. In 2014, estimates were that 60–70 per cent of the people living in Nairobi were living in slum areas (ibid.).

2.2.2. Korogocho and Viwandani slums

Korogocho and Viwandani are two urban slums that together cover about one square kilometre (Emina et al., 2011). These two settlements are densely populated and characterised by lack of basic infrastructure, high unemployment, violence, poor sanitation and poor health indicators (Kimani-Murage et al., 2014).

Korogocho (**Figure 3**) is located in the Kasarani district and is neighbouring the local sewage works and Dandora garbage dump. There are approximately 250 homes (rooms) per hectare in Korogocho and most houses are built from mud and timber, with tin cans as roof material (Emina et al., 2011). Korogocho is located north-east of Nairobi, approximately ten kilometres from the city centre and seven kilometres from Viwandani (Emina et al., 2011; Google Maps, 2015b).



Figure 3. Korogocho (Google Maps, 2015b).

Viwandani settlement (**Figure 4**) is located in the Makadara district on the outskirts of an industrial area, surrounded in north by the Donholm railway and subway station and in the south by the heavily polluted Ngong river. Most structures here are made out of iron sheets and tin walls with iron sheet roofs (Emina et al., 2011; Google Maps, 2015c).

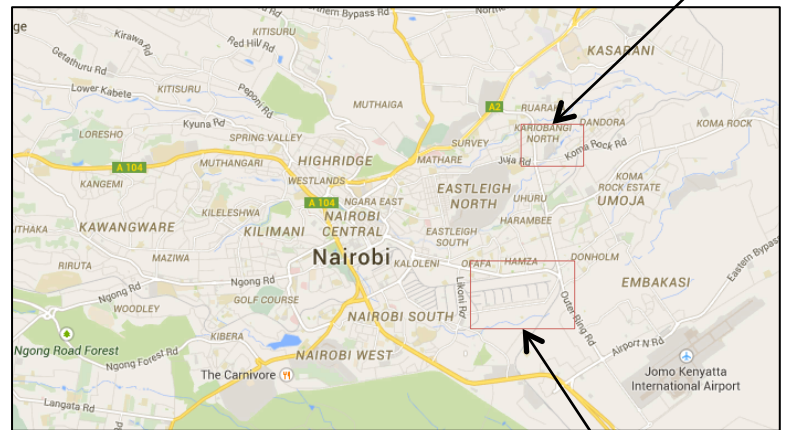


Figure 2. Nairobi (Google Maps, 2015a).

As of 2008, there were no governmental health facilities within the slum areas. Such could be found and accessed in the surrounding legal neighbourhoods (Ndugwa and Zulu, 2008). However, slum inhabitants more often sought care in the informal private sector clinics and retailers situated within the slums (ibid.).

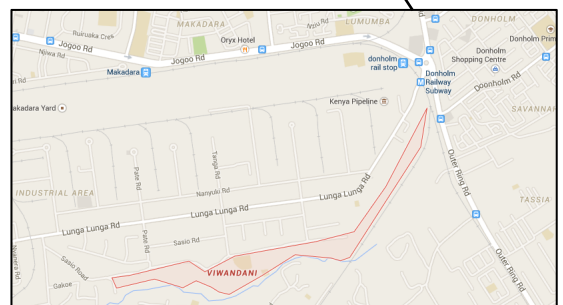


Figure 4. Viwandani (Google Maps, 2015c).

In 2009, Korogocho was characterised by a more stable community, with residents staying for many years, whereas Viwandani had more temporary youthful inhabitants, seeking job opportunities in the city (Emina et al., 2011). At this point in time, differences in child health indicators could also be seen. The U5M rates (per 1,000 live

births) were 93 and 68 in Korogocho and Viwandani respectively. The IM rates (per 1,000 live births) in the same year were 73 and 47 respectively (ibid.).

2.3. Study population

2.3.1. Nairobi Urban Health and Demographic Surveillance System (NUHDSS)

The NUHDSS is an open surveillance cohort and was set up to fill the evidence gap in understanding the consequences of rapid urbanization and the rapidly growing concentration of poverty and ill health in slum settlements (Beguy et al., 2015). The site was set up by the African Population and Health Research Centre [APHRC] in two slum settlements, Korogocho and Viwandani, in 2002 (ibid.). The main objective of the site was to provide a longitudinal platform for investigating linkages between urban poverty and well-being with outcomes including health, demographic dynamics and schooling (Emina et al.,

2011). Between 2003–2009 the population monitored increased with 16 per cent (ibid.).

In 2009, 65,000 inhabitants in 25,000 households registered in Korogocho and Viwandani slums were monitored by the NUHDSS (**Figure 5**). The surveillance system has been running since 2002 (Beguy et al., 2015) and all regular residents in the predefined study areas are included in this open cohort (Emina et al., 2011).

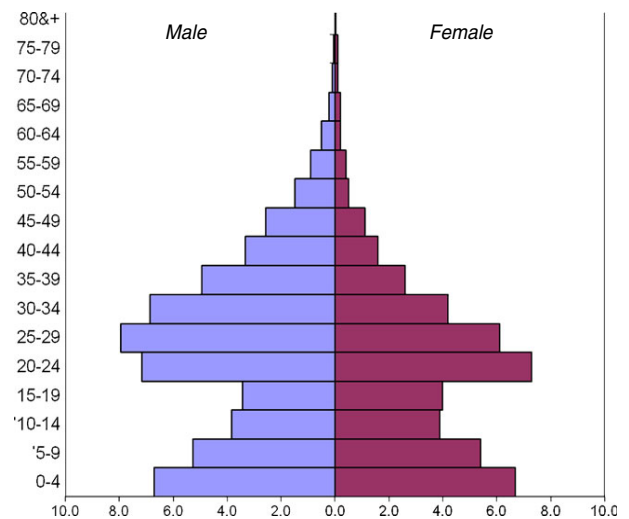


Figure 5. Population pyramid of the NUHDSS 2009 (Emina et al., 2011).

2.3.2. Data collection

For all mortality events recorded during the routine NUHDSS rounds, three times annually, a detailed verbal autopsy questionnaire was filed out (Kyobutungi et al., 2008). Several visits were made to the affected household, to ensure that a credible respondent was interviewed (ibid.). A total of 19 interviewers conducted face-to-face paper-based interviews, with next of kin or caregivers, in assigned areas of Korogocho and Viwandani slums (African Population and Health Research Center (APHRC), 2015a). The experienced interviewers had extra training in data quality control before each cycle of data collection (Mutisya et al., 2010). In addition, supervisors

were present and quality control officers performed random spot-checks on ten per cent of the questionnaires (African Population and Health Research Center (APHRC), 2015a). Computerised as well as visual corrections were then made (ibid.).

This thesis was carried out using secondary microdata from the 17th to the 24th round of the ‘verbal autopsy’ section of the NUHDSS. These survey data included all deaths, with assumed causes, occurring in the Korogocho and Viwandani areas, between 2008–2010, detected every four months i.e. three rounds annually, during the routine NUHDSS rounds. The 17th round started 1 January 2008 and the 24th round ended 31 December 2010. The microdata sets were acquired from the APHRC Microdata Portal and downloaded to a private computer.

2.4. Variables

The primary focus of this thesis was on the first and last stage in the causal chain presented in the background (**Figure 1**) i.e. *season* (predictor) and *mortality* (outcome). *Age at death* and *gender* were also seen as predictors. Possible effect modifiers were considered to be *maternal socio-economic status, physical environment* and *treatment & prevention*, these were considered to be controlled for in the sampling, as the whole population was included in the sample, deriving from similar environmental and socio-economic conditions.

	Variable	Definition
Outcome:	<i>Mortality</i>	Yes, No
Predictors:	<i>Age at death (days)</i>	U5M: 0–1824
		NM: 0–27
		PM: 28–364
		CM: 365–1824
	<i>Date of death</i>	Month, year
	<i>Gender</i>	Female, male

The *age at death* variable was already calculated and expressed in *days* in the original dataset. The researcher used this variable to distinguish U5M from the total mortality data and then subgrouped these data using definitions from UNICEF et al. (2007), as displayed in **Table 1**. Events of early neonatal mortality (0–7 d.) and late neonatal mortality (8–27 d.) during the studied time period was low, 48 and 11 cases respectively, hence the data from these two groups was merged and labelled NM. Stillbirths were not specified in the datasets. The mortality groups are not

mutually exclusive i.e. U5M comprises all mortality events and the other groups contain deaths that occur in the respective age span, as displayed in **Table 1**.

2.5. Statistical methods

Microsoft Excel for Mac 2011 version 14.4.7 [Excel] as well as R statistical software version 3.1.1, Mavericks build from 2014 (R Core Team, 2014), with the Rcmdr package version 2.1-0 [Rcmdr] (Fox, 2005) were used to handle the datasets.

Initially, the original datasets in .dta format, as used in Stata statistical software, were imported in to Rcmdr and converted to tab separated .txt format, for readability in both Rcmdr and Excel. Then, the datasets were cleaned, keeping for the study relevant variables i.e. *date of birth*, *date of death*, *year*, *gender* and *age at death*. All cases collected during the rounds that had occurred in previous years were manually deleted, keeping mortality cases from 2008–2010 alone. All numbers were rounded to two decimals. There was no missing data in the datasets.

The *age at death* variable was used to create a new variable, *age group*, categorised by using the explained definitions in **Table 1** and labelled *NM*, *PM* and *CM*. The variable *Date of death* was considered to correspond to the *seasonal* factor and was converted to represent the month and year only and was relabelled *month of death*. The *year* variable was converted to be categorical.

By calculating multi way frequency tables in Rcmdr, looking at the *month of death* variable together with *year*, *age group* and *gender*, crude distributions and means for the different years were found. Thereafter, the time series decomposition and figures modelling was carried out in Excel.

2.5.1. Time series

Repeated sequence observations over a period in time e.g. monthly, daily or trimestral, can be used for time series analysis. This is a method used in attempts of e.g. forecasting and understanding seasonal variations and trends (Dodge, 2008). The method is commonly used in economics (ibid.) and is also useful in epidemiology studies assessing trends of e.g. outbreaks and mortality (Antunes and Waldman, 1999).

2.5.1.1. Decomposing time series

A time series can be decomposed into four components: *secular trend*, *seasonal variation*, *cyclic fluctuations* and *irregular variations* (Dodge, 2008). The mathematic model used in this thesis to describe the seasonal variation was the multiplicative (ibid.): $Y_t = T_t \cdot S_t \cdot C_t \cdot I_t$

The time series data on mortality events from the NUHDSS, expressed as month and year (Y_t), was imported into Excel. Then, as explained by Dodge (2008), the data was decomposed by first smoothing the *irregular variations* (I_t) and keeping the *cyclic fluctuations* (C_t) by using a moving average [MA], which was presented as a smoothed line when graphically displayed. This in turn, made it easier to interpret the seasonality of the data, as irregularities had been smoothed (ibid.).

The MA was calculated by averaging five-month sequences, two months prior and two months after the corresponding month (**Figure 6**) (ibid.). Then, by dividing the crude data with the matching MA, the difference from the MA was found. By averaging this output from all similar months over the three years, the seasonal component (S_t) for the study period had been decomposed, reflecting the *seasonal variation* (ibid.). The same procedure was carried out for all age and gender strata. The findings were calculated and then visualised in Excel. The trend component (T_t) was not considered, as it was not in line with the research objectives.

Figure 6. Moving average example.

Month of mortality	Mortality events	Moving average
2008-Jan	6	
2008-Feb	5	
2008-Mar	7	➤ 6
2008-Apr	6	➤ 6
2008-Mar	5	7
2008-May	6	9

2.5.1.2. Seasonal index

There are several methods for calculating seasonal indices e.g. percentage of mean, relative chains and moving average ratio (Dodge, 2008). The indices used in this thesis were found through calculating percentage of mean, as explained by Dodge (2008). This was done by first finding the monthly mortality average over the season, i.e. twelve month period, for each of the years analysed. Then, the crude mortality for each of the months was divided with the mortality average in the corresponding season to find the proportion attributable to the specific month. Lastly, by averaging the proportion from all similar months over the three years, the monthly

proportion over the study period i.e. the seasonal index was generated. The above-described procedure was executed on all age and gender groups separately.

3. Ethical Considerations

In the Helsinki Declaration (WMA General Assembly, 1964) it is stated that all medical research involving human subjects ought to take ethical concerns into consideration. Discussed below are some of the basic principles of the declaration, applicable to the presented thesis.

3.1. Ethical clearance

The NUHDSS has been granted ethical clearance by the Ethical Review Board of the Kenya Medical Research Institute [KEMRI] (Beguy et al., 2015).

3.2. Informed consent

Informed consent was obtained from all respondents on enrolment. The field workers were trained in research ethics and verbal consent was obtained from all respondents in every round of NUHDSS data collection (Abuya et al., 2012). Still, the respondents refusal rate has been low (two per cent) since the initiation of the NUHDSS (Beguy et al., 2015), possibly reflecting the communities trust in the research team (Molyneux et al., 2005) or arguably participants' insufficient knowledge of terms of participation and unequal power-relations between researchers and respondents (Molyneux et al., 2004).

3.3. Confidentiality

All data had been encrypted with ID-codes to ensure confidentiality (Beguy et al., 2015) and all original datasets will be deleted once the thesis has been defended. All datasets used in this thesis have been requested, free of charge, through the APHRC Microdata Portal and have only been handled on one computer.

3.4. Benefits

Nothing was stated about the remuneration of the participants. However, the APHRC is regularly hosting free health camps in order to 'give back' to the communities (Beguy et al., 2015). Furthermore, through compiling evidence from the study population, it is likely that future benefits can be provided through tailored interventions.

4. Results

4.1. Descriptive statistics

As shown in **Table 2**, there were in total 822 observed mortality cases in the study population during the study period. The mean age at death was 29 years and the majority of deaths were attributable to males (57 per cent) and the population living in Korogocho (62 per cent). There was a steady measure of mortality events over the three years studied, i.e. each year accounted for approximately one third of the registered deaths.

Table 2 shows child deaths segregated from the total mortality events with a total of 258 under-five deaths: 99 in 2008, 89 in 2009 and 70 in 2010. U5M accounted for 31 per cent of the total mortality during the observed period. 136 cases were female and 122 were male out of the U5M, accounting for 53 and 47 per cent of the under-five deaths respectively. The mean age at death in the U5M group was 317 days, which equals approximately ten months, or in other words: during the post-neonatal period.

The total neonatal, post-neonatal and child mortality cases over the three years were 59, 127 and 72 respectively (**Table 2**). NM, PM and CM accounted for 23, 49 and 28 per cent of the U5M respectively. The mean age at death in the NM group was four (4) days and in the PM group it was 197 days, or approximately six months of age. The largest proportion of deaths (49 per cent) occurred during the post-neonatal period, i.e. from one month up until one year of age.

As shown in **Table 2**, the majority of deceased in the NM and PM groups were girl children, whilst in the older age group (CM) the majority were boys. There were similar proportions of mortality events in the three mortality groups over the observed years, seemingly in a somewhat decreasing trend. 59 per cent of the U5M were in Korogocho and 41 per cent in Viwandani. Graphically displayed in **Figure 7** is the distribution of mortality cases into defined mortality and gender subgroups.

Table 2. Mortality distribution in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010.					
	Mortality, all ages n (%)	U5M 0–1824 d. n (%)	NM 0–27 d. n (%)	PM 28–364 d. n (%)	CM 365–1824 d. n (%)
2008	254 (31 ²)	99 (38 ²)	24 (41 ²)	47 (37 ²)	28 (39 ²)
2009	288 (35 ²)	89 (35 ²)	20 (34 ²)	45 (35 ²)	24 (33 ²)
2010	280 (34 ²)	70 (27 ²)	15 (25 ²)	35 (28 ²)	20 (28 ²)
Total	822	258 (31¹)	59 (23³)	127 (49³)	72 (28³)
Female	353 (43 ²)	136 (53 ³)	34 (58 ²)	69 (54 ²)	33 (46 ²)
Male	469 (57 ²)	122 (47 ³)	25 (42 ²)	58 (46 ²)	39 (54 ²)
Korogocho	520 (62 ²)	151 (59 ³)	35 (59 ²)	74 (58 ²)	42 (58 ²)
Viwandani	302 (38 ²)	107 (41 ³)	24 (41 ²)	53 (42 ²)	30 (42 ²)
Mean age at death	29 y.	317 d.	4 d.	197 d.	785 d.

¹ Per cent of total mortality, all ages

² Per cent of total mortality, corresponding variable

³ Per cent of total U5M

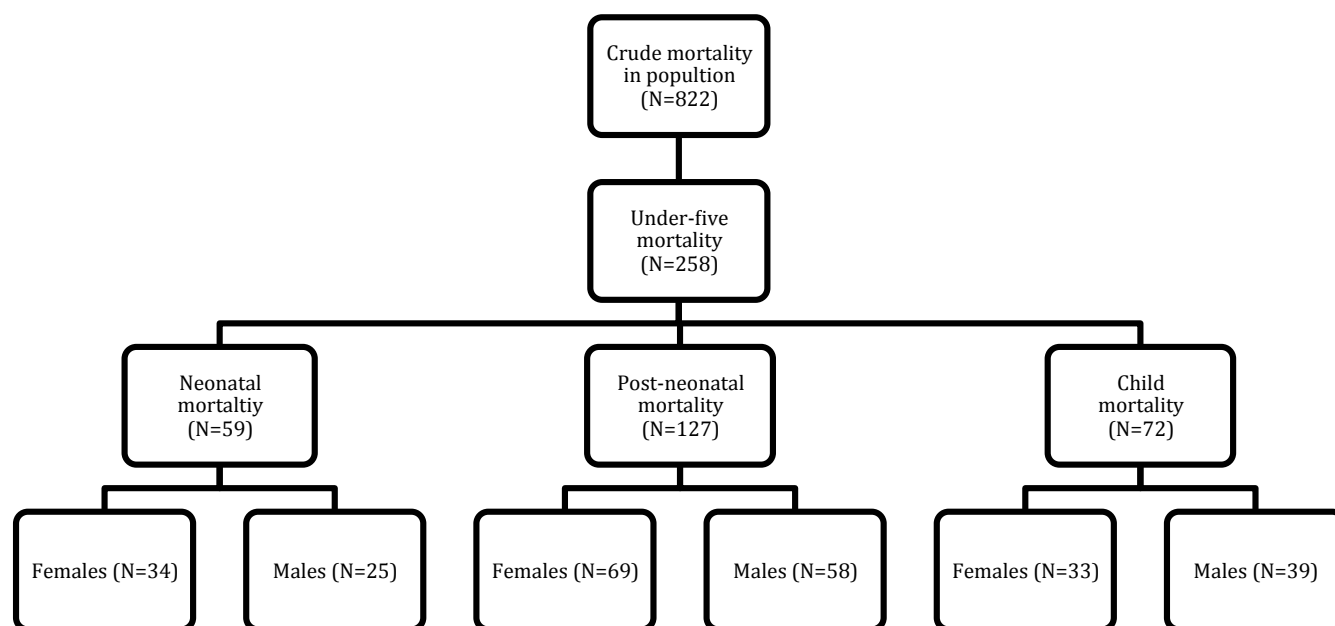


Figure 7. Distribution of mortality cases into defined mortality and gender subgroups, in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010.

4.2. Main results

4.2.1. Seasonal patterns by mortality group

In **Figure 8** the seasonal pattern for the complete time series is graphically visualised, with the computed MA for the observed period. U5M varies over the seasons, reoccurring in regular annual cycles. In the three years studied, seasonal cyclic variations could be seen in all mortality groups, with fluctuations being more prominent in the total U5M and PM groups, which show a clear, annual increase in mortality cases mid-season.

Figure 9 shows the average U5M over the three years observed, distributed per month. What can be seen is that U5M had an annual increase in mortality cases from May–August, with higher numbers also in April and September, corresponding to the displayed patterns in **Figure 8**.

Figure 9 also shows monthly mortality averages segregated by the different mortality groups and results indicate that the groups increase in diverse time-periods: NM had an increase in May–June, PM had two peaks, April–May and July–August and CM had more flattened curve, with its peaks located in July–August and November.

Presented in **Annex: Figure 10** is the crude distribution of the overall U5M cases over the three years, segregated by mortality groups.

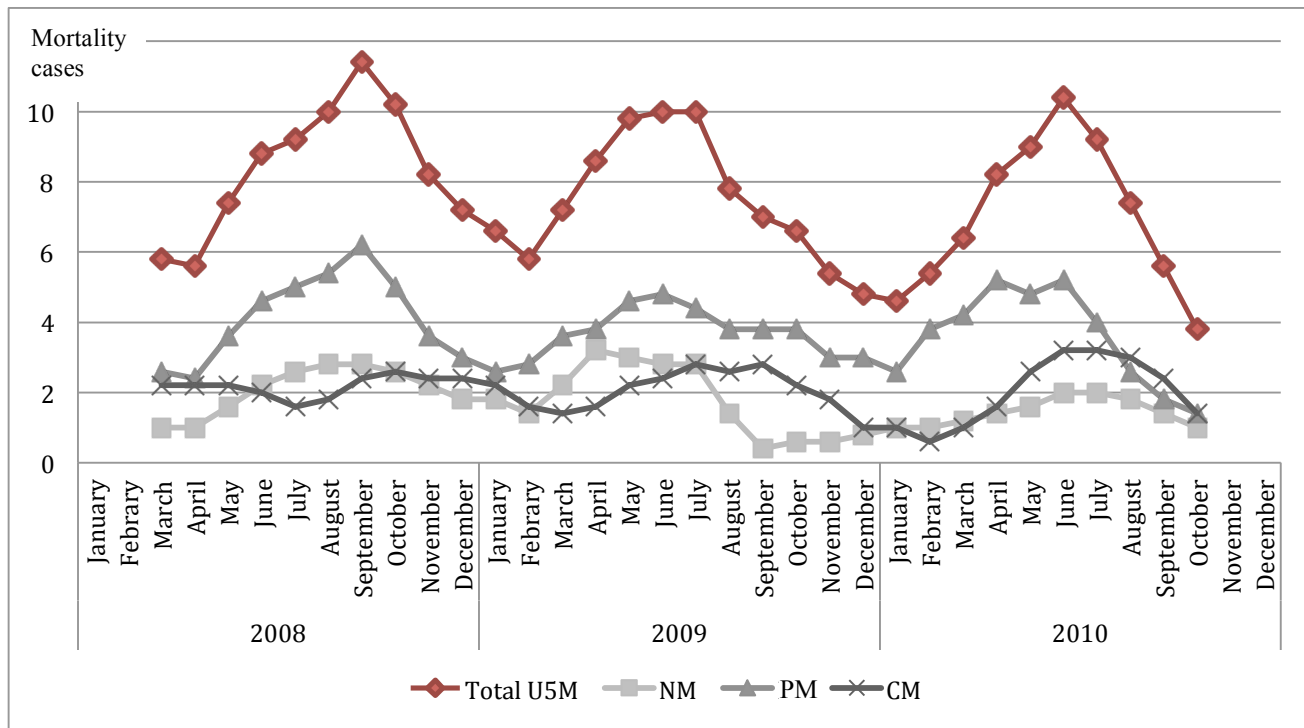


Figure 8. The *moving average* for under-five, neonatal, post-neonatal and child mortality over time in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=258.

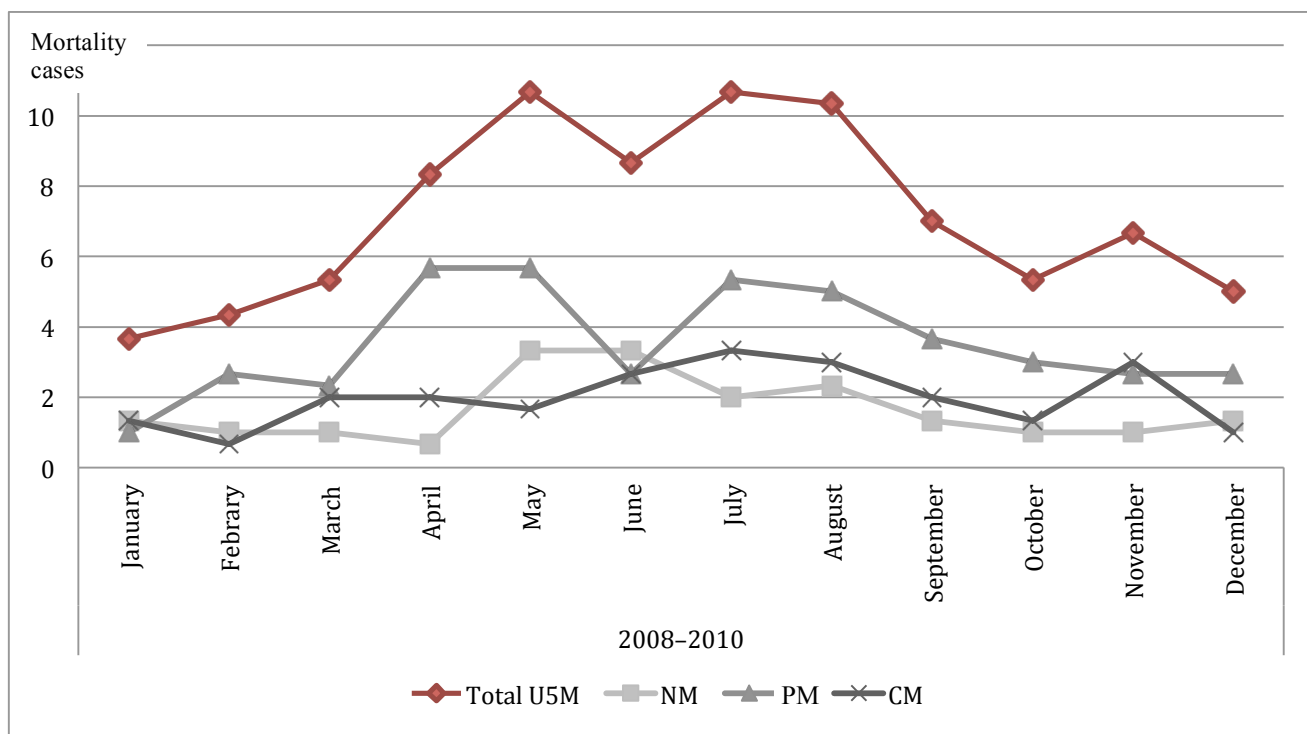


Figure 9. Monthly average of neonatal, post-neonatal, child and overall under-five mortality over time in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=258.

Shown in **Figure 11–14** are the plotted monthly totals of deaths over the whole time series, for each of the mortality groups. The raw data is displayed together with the MA, providing a clearer presentation of seasonal variations in the time series.

Figure 11 displays the overall U5M during the study period together with the MA, which smoothens the irregularities in the data. A clear and regular fluctuation can be seen throughout the time series, with one increase in mortality annually. The total number of deaths during the measured time period was 258. The highest quantity was registered in May 2009, when 15 children under the age of five were registered to have died. The lowest corresponding figures were in January and November 2010, with just one U5M event registered each of the months.

Looking further into U5M, stratified into subgroups, **Figure 12** presents NM with an MA comparison and shows a similar peak pattern as seen in the total U5M group (**Figure 11**). The absolute peak of mortality was in May 2009, where seven out of total 59 NM cases were registered. In this mortality group, several months in the series display no registered cases.

Figure 13 shows the plotted PM data, which is the largest sub-group with 127 registered cases. The MA displays a clear cyclical fluctuation, similar to the U5M (**Figure 11**) and NM (**Figure 12**) series. The highest numbers of mortality cases were in July–August 2008 and April–May 2010, where eight (8) PM cases were recorded each of the months. January and December 2010, were the only months with no PM cases registered.

The total number of CM during the study period was 72 cases (**Figure 14**) with the highest number of cases in November 2008 and July 2010, when six (6) CM deaths were registered. The corresponding MA displays a seasonal fluctuation in mortality events over the time period, however more varied than in the other mortality groups, with peaks at closer intervals and the peak of 2008, situated at the end of the year.

Presented in the **Annex: Table 3** are the decomposed seasonal factors (S_t) for each of the mortality groups, corresponding to the averaged deviation of the crude data from the MA, over the three years, as displayed in **Figures 11–14**.

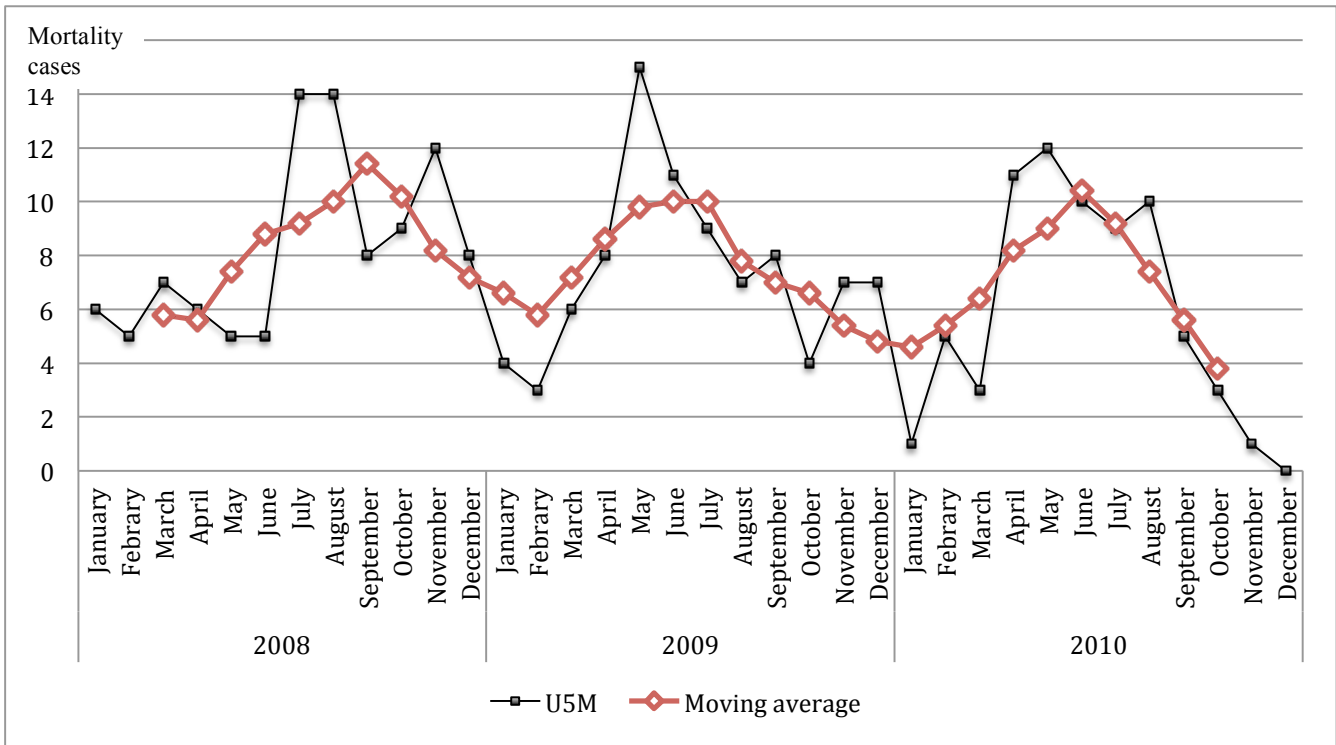


Figure 11. Under-five mortality with MA in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=258.

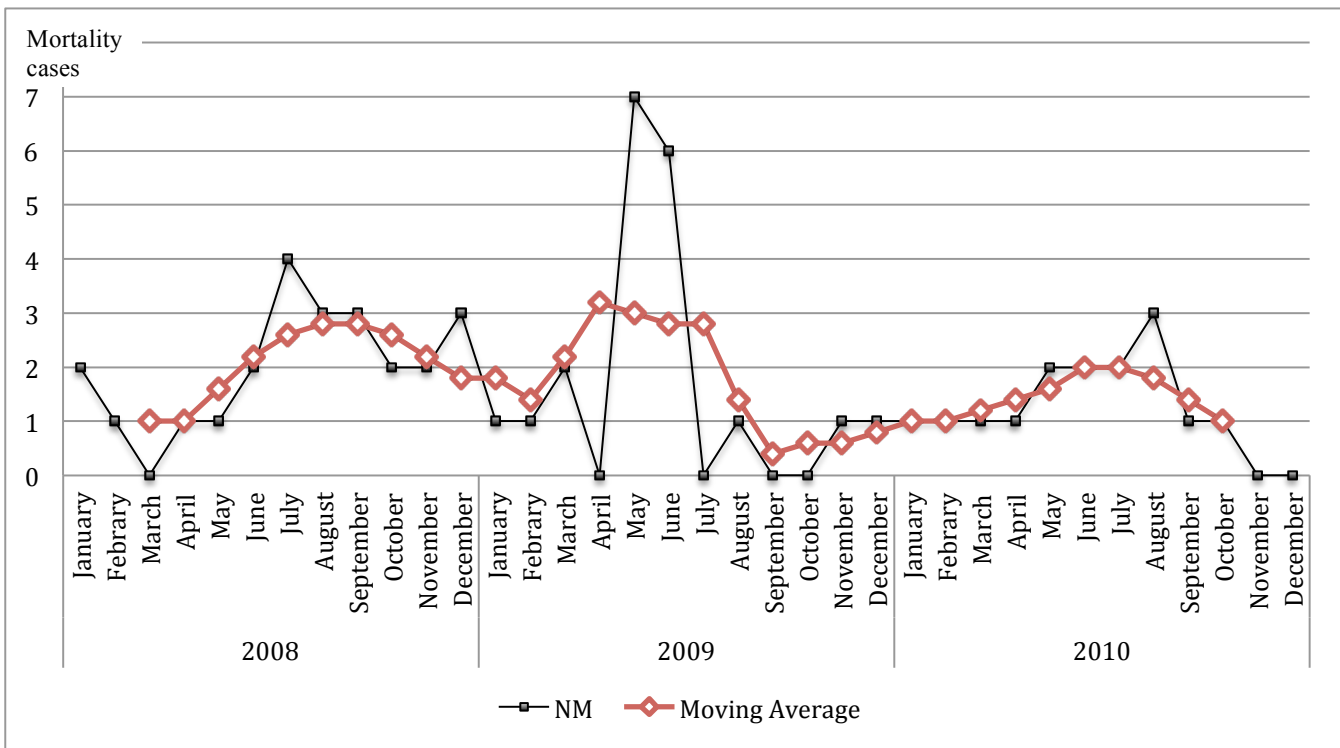


Figure 12. Neonatal mortality with *moving average* in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=59.

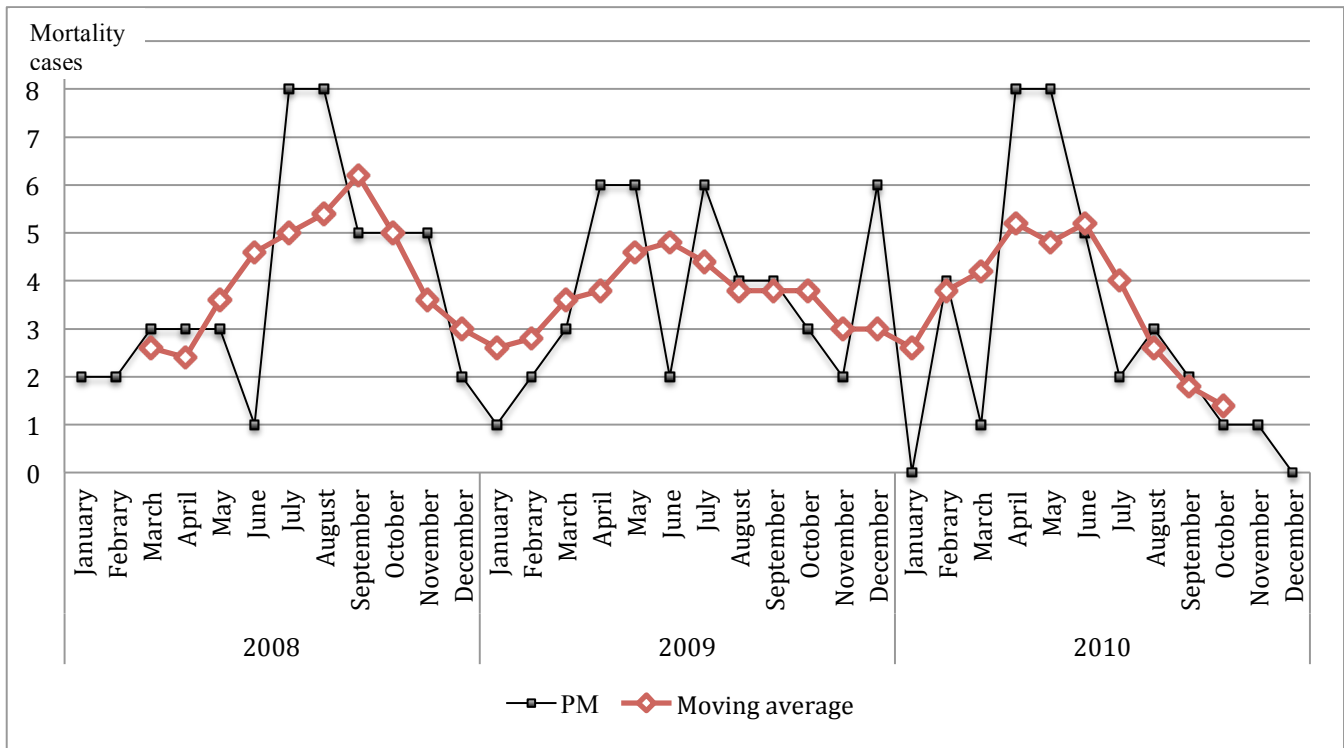


Figure 13. Post-neonatal mortality with *moving average* in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=127.

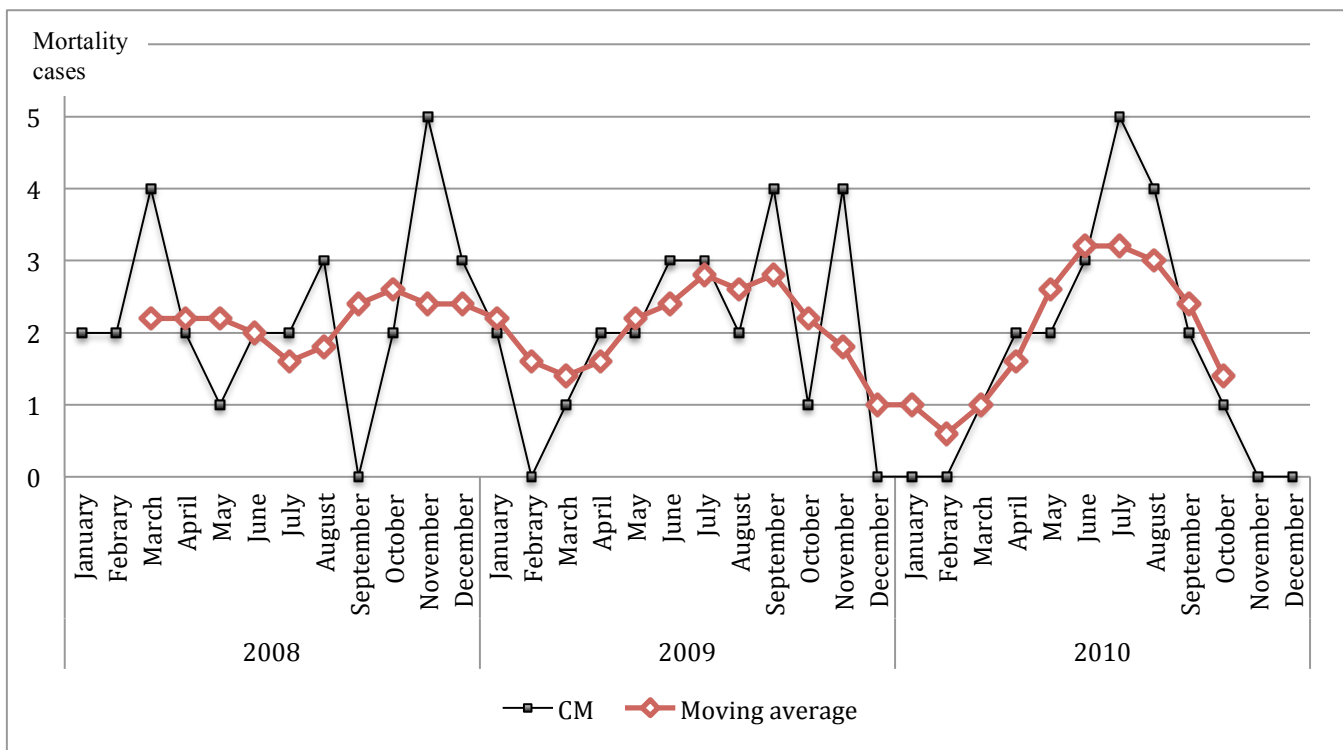


Figure 14. Child mortality with *moving average* in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=72.

4.2.2. Seasonal index by mortality group

The seasonal indices for the different mortality groups are displayed in **Table 4**, with the seasonal average for each mortality group as a reference (1.00). It shows that the total U5M increased from April–August in the analysed time period, with May being the month with the highest mortality, 56 per cent above seasonal average.

With disaggregating data a similar peak-pattern is seen (**Table 4**). NM had its peaks in May–August, with May–June being worst off, where mortality doubled in comparison to the seasonal average. Because of lower mortality in the other groups, this vast increase of NM in May–June (2.1), merely displays as a maximum 56 per cent increase in the U5M index.

Table 4 also shows that PM peaked both in April–May and in July–August, with a maximum of 70 and 44 per cent increase in the respective period. PM is the only group that had high levels of mortality in April, thus not displayed clearly in the overall U5M index. CM intensified from June–August, with an additional peak in November. This late peak separates CM from the other groups, not even visible in the U5M index.

Month	U5M n=258	NM n=59	PM n=127	CM n=72
January	0.48	0.80	0.26	0.62
February	0.62	0.63	0.81	0.29
March	0.72	0.67	0.64	0.94
April	1.23	0.43	1.70	1.02
May	1.56	2.10	1.70	0.88
June	1.27	2.07	0.83	1.39
July	1.48	1.20	1.44	1.79
August	1.45	1.50	1.38	1.56
September	0.97	0.77	1.01	1.07
October	0.71	0.60	0.81	0.65
November	0.86	0.53	0.72	1.38
December	0.64	0.70	0.70	0.43

¹ Seasonal mortality average (for respective group) = 1.00

4.2.3. Seasonal patterns by gender and mortality group

In **Figure 15** the monthly average of U5M is stratified by gender. The fluctuations in registered mortality cases in the two gender groups are similar over the year. Even though the majority of mortality events occurred in the same months, female mortality had one major peak over the year whilst the male group had a less prominent seasonal pattern.

Graphically visualised in **Figure 16**, through the MA for U5M, covering the complete time series, is a clear and regular seasonal fluctuation in both gender strata. Both gender groups display one vast peak annually and proportions of mortality cases are similar in the two groups over the seasons. However, female mortality persistently outnumbers the male cases during the annual peaks.

Presented in **Annex: Figure 17–19**, are the corresponding graphs for the segregated mortality groups, stratified by gender. All gender groups, except female CM (**Annex: Figure 19**), display an annual fluctuation over the observed time period. Furthermore, comparable to the total U5M (**Figure 16**), female mortality exceed the male in the peaks, also in the sub-groups. PM (**Annex: Figure 18**) displays an unexpected inverted pattern in mid-2009, where male mortality surpassed the female.

Annex: Table 5 present the decomposed seasonal factors (S_t) for mortality and gender groups, corresponding to the averaged deviation, of the crude data from the MA, over the three years, as displayed in **Figures 16–19**.

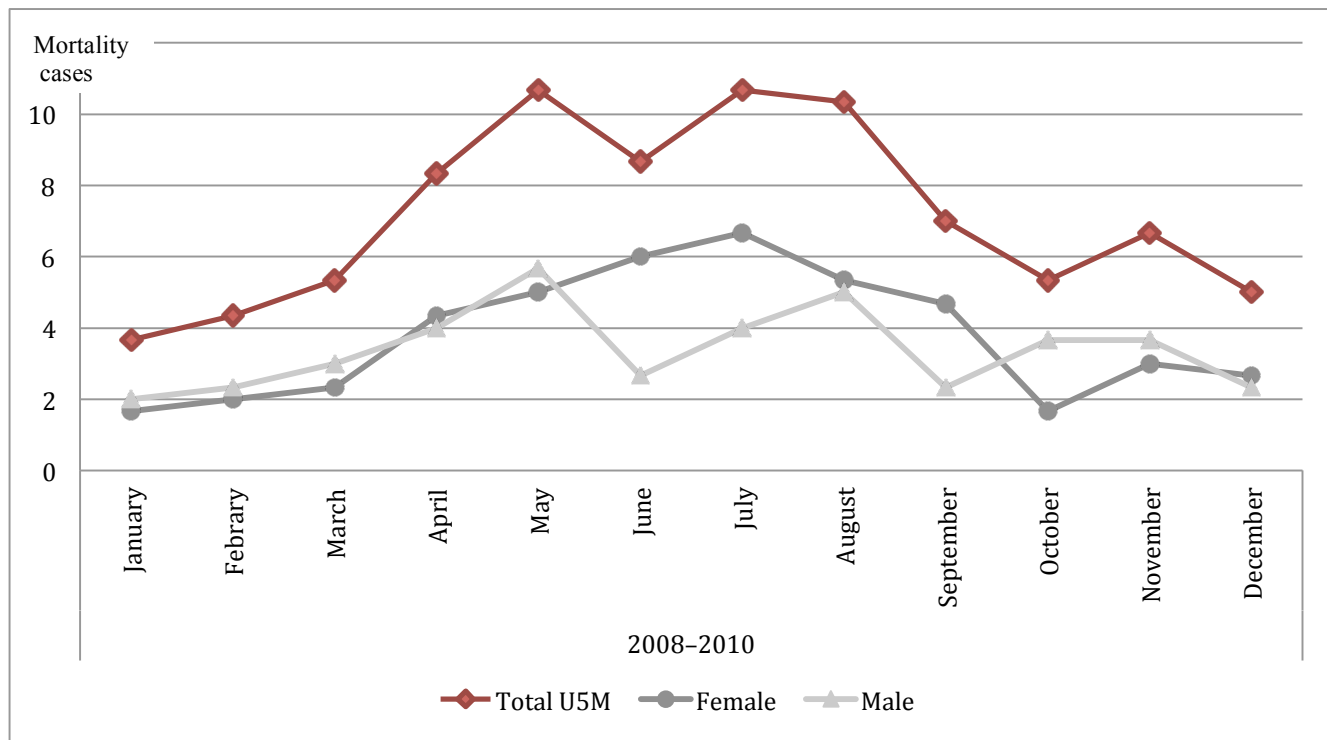


Figure 15. Monthly average of female and male mortality rates and overall under-five mortality over time in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=258 (female=136, male=122).

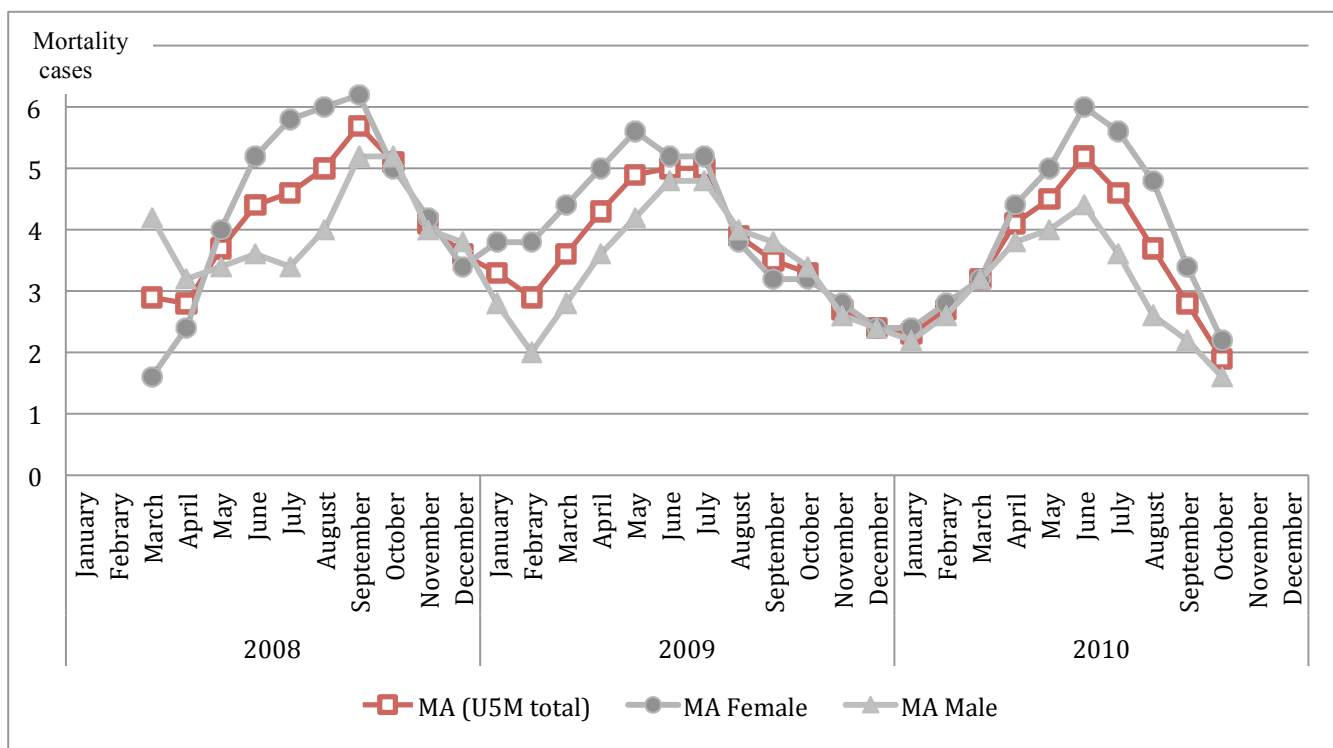


Figure 16. Moving average of under-five mortality over time stratified by gender in Korogocho and Viwandani urban settlements in Nairobi, Kenya 2008–2010. N=258 (female=136, male=122).

4.2.4. Seasonal index by gender and mortality group

In **Table 6** a comparison of the seasonal indices for the mortality groups segregated by gender is displayed. U5M among female children increased from April–September, with an absolute peak in July, with an increase of 78 per cent in mortality cases. Female NM had its worst months in May (1.86) and June (2.88), exceeding the other group indices for June. Female PM had the highest observed mortality in August (1.70). Female CM had the highest concentration of mortality cases in July (3.60) and one additional peak in November (1.60).

Male U5M had two peaks (**Table 6**), one in April–May (1.83) and one in August–September (1.53). Looking at subgroups, male NM had its absolute peak in May (3.00), with threefold the mortality. There was also an escalation in male NM in February (1.57), being the only group to have had an increase in this month. For male PM May (2.03) together with April (1.93) were the worst off months, where mortality doubled. The worst month for Male CM was August (2.33), accounting for more than double the seasonal average of mortality. Male CM additionally had a peak in June (1.56), leaving this group the only one with an increase in this particular month, thus not being reflected in the male U5M.

Month	U5M (n=258)		NM (n=59)		PM (n=127)		CM (n=72)	
	Females (n=136)	Males (n=122)	Females (n=34)	Males (n=25)	Females (n=69)	Males (n=58)	Females (n=33)	Males (n=39)
January	0.43	0.46	0.79	0.67	0.20	0.36	0.53	0.44
February	0.55	0.70	0.00	1.57	1.02	0.52	0.00	0.44
March	0.58	0.88	0.57	0.57	0.56	0.89	0.67	1.00
April	1.18	1.27	0.83	0.00	1.59	1.93	0.53	1.11
May	1.34	1.83	1.86	3.00	1.59	2.12	0.27	1.33
June	1.61	0.88	2.88	0.57	0.83	0.50	1.57	1.56
July	1.78	1.21	1.00	1.48	1.33	1.35	3.60	0.33
August	1.43	1.53	1.45	1.48	1.70	0.87	0.90	2.33
September	1.23	0.66	0.83	0.67	1.57	0.34	1.03	1.22
October	0.46	0.99	0.50	0.67	0.32	1.39	0.90	0.67
November	0.75	0.97	0.29	0.67	0.48	1.05	1.60	1.11
December	0.67	0.61	1.00	0.67	0.80	0.68	0.40	0.44

¹ Seasonal mortality average (for respective group) = 1.00

5. Discussion

5.1. Key results

All groups, regardless of age and gender, displayed a seasonal fluctuation during the observed time period. The overall U5M increased from April–August in the analysed time period, with May–July being the month with the highest mortality. The same pattern was seen in both gender strata. These findings are comparable to Mutisya et al. (2010) who in 2003–2005 found evidence, when analysing quarterly data, of increased risk ratios in U5M and IM in April–September in the same context.

However, there were some peaks that indicate differences between the mortality groups: PM peaked earliest in the season, being the only group having high levels of deaths as early as in April. Male PM and NM had a vast concentration of mortality events in May (2.12 and 3.00 respectively). Female NM was the only group to have the highest level of mortality in June (2.88).

CM was the only group with an additional peak in November, not even appearing in the U5M index. Female CM had the highest proportion of mortality cases in July (3.60), separating it in intensity from the other groups. Although somewhat reflected in the total CM (1.79), this only shows as a 48 per cent increase in the total U5M seasonal index, as a consequence of the other mortality groups being low in mortality in the same month.

5.2. Strengths and limitations (internal validity)

One can argue that these kind of events in life, i.e. the death of a child, are not easily forgotten. Still, the probability of recall bias had to be considered. Data collection was carried out three times annually, giving a recall period of roughly four months. Shorter time periods from event to data collection strengthens the validity of data used (UNICEF et al., 2007).

The sample size in some of the groups might have limited the results and given a more flattened fluctuation, as in the case of CM where the total number of cases were 72 over the three years. This might be avoided in future studies by including more years in the analysis. In the years with

more events, a clearer pattern could be seen. Nonetheless, there was a clear fluctuation in NM with analysis of merely 59 cases, implying that this age group is more prone to seasonal events.

Lack of vital registration (birth and death) among poor and rural families, has been found to be a potential bias, reducing mortality estimates in official statistics (UNICEF et al., 2007). Verbal autopsy has become an essential public health tool for assessing mortality causes and levels in communities where civil registrations is vague and the majority of deaths occur at home, without contact with the health system (WHO et al., 2012). This information is fundamental for e.g. health policy, planning, monitoring and evaluation of interventions (ibid.). The data used in this thesis was derived from a population-based survey, non-relying on national vital registration systems, thus enhancing the validity of the used data.

In the study population, nine per cent (23 cases), of the total U5M were registered as ‘death at age: 0 days.’ UNICEF et al. (2007) discuss the potential bias of age misclassification in e.g. early neonatal mortality, where children who die during the first days are registered as stillbirths. In the data collection stillbirths were not registered as part of NM but as a pregnancy related outcome (African Population and Health Research Center (APHRC), 2015b). However, as births and deaths were not registered at the time of occurrence nor by health professionals, there is a potential uncertainty as to whether the cases registered as ‘death at age: 0 days’ were stillborn or born with vital signs. This could have skewed the registered number of 0-day mortality, which constituted 39 per cent of the NM group. On the other hand, cases of early neonatal deaths in the studied population might have been missed for the same reasons, possibly introducing a downward bias in the analysis.

In general, NM in the studied population displayed a substantially lower proportions of U5M (23 per cent) as compared to the global and overall SSA proportions, being 44 and 34 per cent respectively (UNICEF et al., 2014). In addition to the issue of age misclassification discussed above, a reason as to why the proportion of NM is lower in the slum population in comparison to global figures, is the persistent high numbers of PM and CM in the slums, consequently decreasing the NM proportion (ibid.).

Another potential bias stressed by UNICEF et al. (2007), is the survivor selection bias, potentially omitting cases of births and mortality from the data, of children born to women that dies during delivery. Mothers comprise the largest proportion of respondents (ibid.), which was the case also for the data used in this thesis. Thus introducing a potential downward bias also for orphan children who have died during early childhood (ibid.).

Furthermore, lack of knowledge on historical events limited the interpretation of the findings. An example is that in mid-2009 an unknown event possibly caused NM to peak and the pattern for male PM was inverted in this same time-period. Even though efforts have been made through Internet research and screening for data handling mistakes, an explanation to this change in pattern remains to be found. One hypothesis is an unidentified systematic error that would have occurred in this time period, e.g. a gender misclassification, error when transcribing the survey data or even a change in data collection. Another explanation could be an extraordinary event like the devastating fire in August 2011, where around 100 persons were killed in Sinai village in Viwandani slum, after a pipeline accident (The Guardian, 2011; The Swedish International Development Cooperation Agency (SIDA), 2014) though, nothing similar has been found for the study setting, that could explain the peak in 2009.

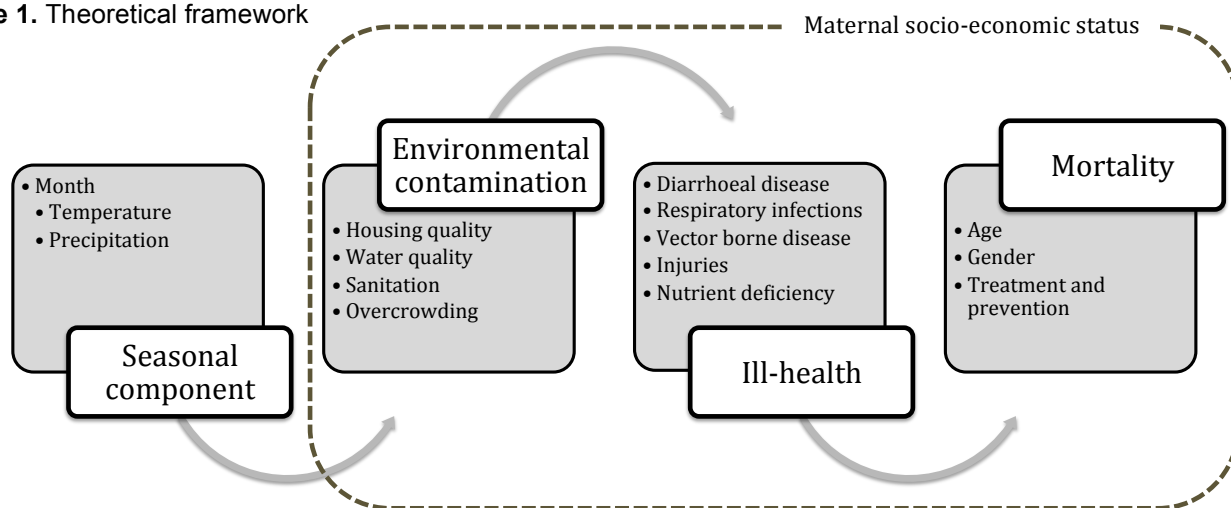
It was found when cleaning the datasets that mortality in previous rounds were registered up to a year after they had occurred, e.g. some of the late 2008 cases were to be found in the 2009 datasets. This means that some of the deaths that occurred in late 2010 might be collected in the coming year and therefore not being part of this analysis, thus, potentially skewing the results.

Lastly, an attempt to receive the historical weather data for the actual years studied, directly from the Kenya Meteorological Department [KMD] was made, without success. Thus, the data from the World Meteorological Organization (2015) (**Figure 20**) were considered applicable to the years 2008–2010. Also, these are perfectly coherent to the ones reported in 2003–2005 (Mutisya et al., 2010) which suggest the data would also be applicable for the years discussed in this thesis.

5.3. Interpretation through theoretical framework (external validity)

The fear that different causes of mortality might have peaks in diverse time periods over the year, thus suggesting that the seasonal effect on overall mortality might be flattened, had to be considered. With this in mind and through discussing the underlying factors in the different stages of the theoretical framework, explained on page 11 (**Figure 1**), an attempt to relate these factors to the results in the seasonal indices was made. The factors *age* and *gender* were discussed throughout the other sections, hence not given their own segment.

Figure 1. Theoretical framework



5.3.1. Seasonal component

The correlation between child mortality and weather has previously been concluded in various LIC-settings. The findings are similar, in both SA and SSA, with increases in mortality events in the rainy and cold seasons in both regions (Burkart et al., 2011; Engelaer et al., 2014; Rumisha et al., 2013). Discussed below are the results from the analysis in relation to the annual weather changes in Nairobi.

5.3.1.1. Monthly temperature and precipitation

Monthly weather reports (**Figure 20**) displaying the average temperature and precipitation over the last 30 years in Nairobi were collected from the website of World Meteorological Organization (2015), which has compiled historical data from the KMD.

Annually, there are two rainy seasons in Nairobi, one in the second quarter (March–May) and one in the fourth (October–December). The second and third quarters of the year correspond to the cold season, with temperatures being lowest in the third quarter (Ye et al., 2009).

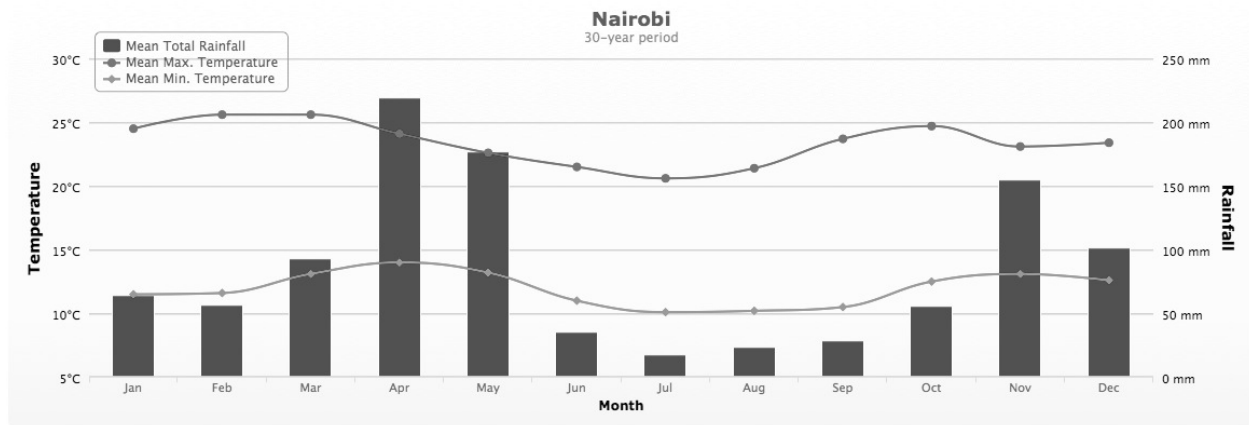


Figure 20. Average temperature and precipitation over the last 30 years in Nairobi (World Meteorological Organization, 2015).

When comparing the study results with the seasonal fluctuations in rainfall and temperature (Figure 20), a pattern emerges. Overall mortality seems to increase together with the intensification of rain (April–May) and remains high throughout the colder season (June–August). When segregating, we see that NM had its worst prevalence when the weather changed from wet to cold (May–June). PM had its worst share of cases during the wettest and the coldest months of the year, namely April–May and July–August. Seemingly, CM was more affected by the cold season (June–August) and actually was the only group that seemingly susceptible to the second rainy season in November–December.

When looking at the gender strata, overall female U5M seem to have had its peak just after the first rainy period in June–July, whereas Male U5M had its absolute peak in May, during one of the wettest months. Both gender groups have corresponding peaks in NM (May–June), directly correlating with the first rainy period. Similarly, PM increases in the rainy April–May. Furthermore, female PM had an additional peak in August, mid coldest season. The group that arguably stood out the most was CM. The female CM had its absolute peak in cold and dry July

and then again in November, during the second annual rainy period. Male CM had all its increases in mortality during the coldest seasons, with peaks in June and August.

The findings are confirmed by Mutisya et al. (2010) who analysed surveillance data from the same Nairobi slum settlements (Korogocho and Viwandani) over three years, 2003 to 2005. They found that there was a significant peak in U5M in the second quarter (Apr–Jun) and a borderline significant peak in the third quarter (Jul–Sep), correlating with the onset of the rainy and cold period, increasing the risk of mortality with 56–60 per cent. Another interesting finding was the gender inequality in mortality, significantly favouring girl children (ibid.). Not corresponding to the findings in this thesis.

In other SSA settings, Rumisha et al. (2013) made similar findings in rural Rufiji district, Tanzania, where the annual rainy period could be associated with an increase in PM. Moreover, in rural Ghana, Engelaer et al. (2014) could associate the annual rainfall to child and old age mortality events. However, children in this study were classified as age 0–14 years, thus not fully comparable to the findings in this thesis. Hypothetically, had the data been segregated further, more profound results would have been attained.

5.3.2. Maternal socio-economic status

The direct linkage between maternal socio-economic status and child health outcomes has been thoroughly studied. Studies conducted in SSA have e.g. shown correlations between maternal educational level and child health and survival (Amouzou and Hill, 2004), child immunisation (Onsomu et al., 2015) and child nutritional status (Abuya et al., 2012).

Amuyunzu-Nyamongo and Taffa (2004) conducted focus group interviews, in four slums in Nairobi, including Korogocho and Viwandani, in 2002. The respondents concluded that poverty was the only reason people decided to reside in a slum settlement. It was also stated that poverty was the one reason not to act on their understandings on the environments impact on adverse health in children.

Emina et al. (2011) found that the proportion of households living below the poverty line in the NUHDSS areas had decreased from 55 per cent in 2006 to 35 per cent in 2009. Nonetheless, out of the 34,000 respondents above the age of eighteen, 27 per cent said to be economically inactive, i.e. not generating an income. When looking at gender differences the proportions of economically inactive were 50 and 9 per cent for females and males respectively (ibid.). Furthermore, Abuya et al. (2012) found, in a cohort study nested in the NUHDSS, that 77 per cent of the mothers had primary education or less.

Fotso et al. (2012) found that when discriminating stunting prevalence in the slums in Nairobi between the four dimensions: monetary, assets, food and subjective poverty, findings show that younger children aged 6–11 months are the most susceptible to food poverty and that assets and subjective poverty are strong predictors for stunting in older aged children, leaving them at a 3.9 and 4.4 greater risk respectively compared to richer households.

Amuyunzu-Nyamongo and Taffa, (2004) concluded that mothers actually did know what was causing the ill-health of their children in the Nairobi slums, e.g. eating dirty food causes diarrhoea and stagnated water causes malaria. However, since the living conditions prevent mothers from acting on underlying causes, interventions aiming at behavioural change should not be in focus, but rather structural and environmental improvements. The study contributes with a deeper understanding and gives yet another dimension of this complex problem of what is needed to combat childhood illnesses.

5.3.3. Environmental contamination

The World Bank (2001) emphasizes that an inadequate environment is a threat to public health and might contribute to the global disease burden. The hazards were divided into two categories: traditional health risks, i.e. unsafe water and sanitation, indoor air pollution and vector exposure, and modern environmental risk factors, such as pollution from transport and industries and agrochemicals. Also stressed was that poverty puts people at greater risks, with a ‘double burden’ of risks, both traditional and modern (ibid.).

Changes in weather might affect the environmental conditions (Altizer et al., 2006) and this may be even more accentuated in the susceptible setting of a slum. Discussed below are the different parameters from the framework (**Figure 1**) and how these might affect ill-health of children living under these conditions.

5.3.3.1. Water, sanitation and hygiene [WASH]

Clean and safe drinking water and appropriate sanitation are the main protectors of childhood diarrhoea and other diseases (UNICEF and WHO, 2009). In 2008 and 2009 the vast majority (91–95 per cent) of the respondents in the NUHDSS declared to have bought piped water from the kiosk, which was said to be contaminated from surrounding sewers and refuges (Emina et al., 2011). As much as 75 per cent stated not to have access to a garbage disposal arrangement and to use the rivers for disposal (ibid.). Furthermore, in 2009, 54 per cent used a shared toilet and 44 per cent used a toilet without a flushing mechanism. This proportion was similar for both years. Merely 1 per cent of the population had access to a private toilet (ibid.).

Comparably, Kimani-Murage & Ngindu (2007) investigated the water quality and toilet behaviour in Langas slum in Nairobi in January–June in 1999 and found that 98 per cent of the adults and 70 per cent of the children used pit latrines. Many of the latrines were situated 1–15 m (38 per cent) from a water source, far closer than recommended. Consequently, 70 per cent of the sampled wells were contaminated with *E. Coli* or *thermo-tolerant coliform bacteria*, both being a prominent cause of gastrointestinal diseases (ibid.). In a slum settlement, in Blantyre city in Malawi, Palamuleni (2002) found when sampling the surface and groundwater sources, that the onset of the rainy season negatively affected the water quality substantially. Here the usage of pit latrines was 59 per cent.

In an observational study, Muoki et al. (2008) stressed that cooking practises were insufficient in the Mukuru slum in Nairobi, where personal hygiene when cooking, water quality and waste disposal practises were far from suitable for maintaining the health of children. Nearly half, 47 per cent, did not wash their hands before handling foods and 91 per cent of leftovers were stored inappropriately and served again (ibid.).

Efforts have been made to upgrade the Nairobi slums in the past. UN-Habitat has together with the Government of Kenya co-funded several projects aimed at e.g. mapping the slummed areas of Nairobi and improving water and sanitation (UN-Habitat and KENSUP, 2008). However, no evaluation reports seem to have been conducted looking at the impact of these improvements. In India, Butala et al. (2010) conducted a study with the attempt to correlate health outcomes with slum upgrading and found that water and mosquito borne diseases decreased radically. Nonetheless, UN-Habitat & KENSUP (2008) emphasise the complexity of successful slum upgrading, as it has to be holistic and tailored to each setting.

5.3.3.2. Housing quality and overcrowding

Densely populated living areas with overcrowded houses, such as slums, where lack of proper ventilation, hygiene and hazardous environments, increase the risk of disease transmission (WHO and UN-Habitat, 2010). Furthermore, overcrowded living increases mental stress and induce violent behaviour, e.g. sexual and intimate partner violence and child maltreatment (ibid.).

Some evidence have been found that carbon monoxide poisoning among children, originating from heating appliances, is more common in cold seasons (UNICEF and WHO, 2008). It has also been argued that an increased risk of pneumonia in children partially might depend on the choice of cooking fuel. Indoor cooking with solid biomass fuels, such as dung, wood and coal, has been seen to increase the risk of lower respiratory infections (Rudan, 2008; Smith et al., 2000).

In Korogocho and Viwandani, 80 and 87 per cent said to have used kerosene for cooking respectively, while 18 and 12 per cent used other cooking sources, such as charcoal, briquettes and dung (Emina et al., 2011). However, nothing is reported of the location of the cooking facilities, indoor or outdoor, or the means of heating the houses.

Comparably, Muller et al. (2003) found that in an informal slum settlement in Durban in South Africa, due to densely populated housing areas, cooking was predominantly carried out indoors, in the only room available. In this setting, with the prevalence of kerosene usage for cooking being 87 per cent, the children were exposed to kerosene more than ten-fold the recommended time, putting them at risk of increasing respiratory symptoms (ibid.).

Arguably, indoor cooking practices increase during the rainy and cold seasons, when the outdoor climate might inhibit outdoor cooking. However, no published studies have been found to support this statement.

5.3.4. Ill-health

There are several environmental mechanisms that induce seasonal variances of infectious disease. These include e.g. seasonal pattern in the social behaviours, seasonal temperature and rainfall (Altizer et al., 2006). Discussed below are the different *ill-health* conditions from the applied framework (**Figure 1**) presented with evidence on how these might be seasonally affected.

5.3.4.1. Diarrhoeal disease

Diarrhoea was the second largest under-five killer worldwide (Requejo et al., 2014) and is a common symptom of gastrointestinal infections caused by various bacteria and viruses (UNICEF and WHO, 2009). *Rotavirus* is the leading cause of acute diarrhoea in children worldwide. Other common bacteria are *E. Coli* and *Shigella* (ibid.). Similarly, Kyobutungi et al. (2008) estimate that diarrhoea accounted for 20 per cent of all U5M in Korogocho and Viwandani in 2003–2005, thus being the second most common cause of death in this population.

In a review from the Cochrane collaboration (Ejemot-Nwadiaro et al., 2009) it was concluded that transmission of pathogens causing some of the diarrheal disease predominantly occur through contaminated food and water or through direct contact with faeces, i.e. faecal-oral route. It was concluded that by breaking the contamination chain through hand washing a reduction of 32 per cent (low-income setting) and 39 per cent (high-income setting) is possible (ibid.).

No studies were found looking at whether diarrhoeal mortality in Nairobi might be seasonally varied. Nonetheless, in a slum in Dhaka, Bangladesh, Haque et al. (2003) found that under-five diarrhoeal incidence was significantly peaking in the annual rainy season. However, Gladstone et al. (2008) found that gastrointestinal morbidity increased in a slum in Vellore, south India during the warm and dry season. These ambiguous findings validate the difficulties of assessing diarrhoeal disease incidence, and that the different underlying biases, e.g. confounding and misclassification, might be hard to address.

An example of this could be what Haque et al. (2003) found in a slum in Dhaka, Bangladesh when analysing stool samples of children with acute diarrhoeal infections. They saw that *Histolytica*-infections were present all-year-round in 70 per cent of the children, thus indicating that the pathogen reservoir was present in the surroundings of the children, e.g. in the drinking water. This might also be the case in the slums of Nairobi, where Kimani-Murage & Ngindu (2007) found that most of the water sources in one of the slums were contaminated with *E. Coli*, a pathogen causing acute diarrhoea, thus hypothetically stagnating the seasonal effect of child diarrhoeal mortality.

5.3.4.2. Respiratory infections

In 2012, pneumonia was a principal cause of U5M globally (Requejo et al., 2014). The most common viral cause to childhood pneumonia globally has been found to be the *respiratory syncytial virus*, increasing the risk to get a secondary bacterial infection, which are common in young children living in LMIC (Rudan, 2008). The *respiratory syncytial virus* has shown to be seasonal in all geographical settings, with the incidence having a sharp peak over two to four months, occurring in the rainy season in tropical regions (ibid.). These conclusions correspond well to the findings in this thesis.

Similarly, an association between the annual wet and cold season and mortality due to pneumonia among children under five in Nairobi was found by Ye et al. (2009) who looked at NUHDSS data from the years 2003–2005. Findings were that pneumonia was the overall leading causes of death during the studied period, accounting for 26 per cent of all U5M. The second quarter was found to be the peak period for pneumonia, with double the risk compared to the fourth quarter. Additionally, being older than one year seemed to have a protective effect on pneumonia (ibid.).

The same age correlation was found in a slum cohort in Vellore, south India, where young age children (3–5 months) were found to have an increased risk of pneumonia (Gladstone et al., 2008). Findings were also that pneumonia incidence among children under five could be associated with the seasonal cold and wet season. Additionally, exclusive breastfeeding seemed to have an protective effect on pneumonia (ibid.).

Findings in this thesis suggest that NM doubled in the wet months of May–June, thus indicating that pneumonia might have caused these deaths. The relation was also supported by Ye et al. (2009) who proposed an annual intensification of pneumonia child deaths in the same months and setting.

These findings could explain some of the seasonal mortality patterns in the different mortality groups, as mortality in all groups, regardless of gender, seems to increase in rainy April–May, assumingly being cases of pneumonia and/or diarrhoea.

5.3.4.3. Vector borne disease

Hotez and Kamath (2009) stress that many of the common tropical diseases, e.g. helminth and bacterial infections, mostly affecting the poorest populations in SSA, have been neglected in favour of other more known infections, e.g. malaria. Still, these neglected infections are estimated to contribute vastly to the burden of disease and child mortality in many of the SSA countries, Kenya included (ibid.). Limited information has been found of the prevalence estimates or the seasonality of many of these neglected diseases. Nonetheless, slum inhabitants in Korogocho and Viwandani perceived skin infections in children to be the one of the most common child health issues (Amuyunzu-Nyamongo and Taffa, 2004).

From 2010 to 2011 Mbae et al. (2013) examined stool samples from children seeking help for diarrhoeal symptoms in Nairobi, and found that 39 per cent in the public clinic and 21 per cent in the hospitals had intestinal parasites. A total of fifteen different parasites were found. Results also showed that older children were more exposed to infections and HIV-infected children were more likely to be effected by any parasite. The findings were found to correlate with the seasonal rain fall (Mbae et al., 2013).

In Kenya, malaria has its seasonal peak from June to August (Division of Malaria Control [Ministry of Public Health and Sanitation] et al., 2011). However, in Nairobi and the central highlands of Kenya, low temperatures prevent malaria to develop completely and thus the capital is situated in a low-risk malaria endemic area (ibid.).

By auditing and going through medical records in health clinics, Mudhune et al. (2011) estimated that malaria accounted for 9 per cent of all under-five out patient diagnosis in Nairobi, in August 2009–July 2010. Additionally, Kyobutungi et al. (2008) estimated that malaria accounted for 3.5 per cent of all U5M in the slums of Nairobi in the years 2003–05. Nevertheless, Amuyunzu-Nyamongo and Taffa (2004) found in focus groups discussions, that malaria was perceived by slum residents to be the third biggest threat to children's health in Nairobi slums, following respiratory- and gastrointestinal illnesses.

5.3.4.4. Injuries

Globally, the leading causes of injury-induced deaths in children under five are drowning, road traffic injuries and fire-related burns (UNICEF and WHO, 2008). Children living in poverty account for the largest proportion of injury deaths, and children in slums are at even greater risk, as a consequence of not benefitting from protective measures (ibid.). In Kenya, injuries accounted for 6 per cent of the annual U5M in 2012 (Countdown to 2015, 2014) and in Korogocho and Viwandani the proportion was similar (6 per cent) in 2003–2005 (Ziraba et al., 2011).

Ziraba et al. (2011) investigated the main causes of injury-induced mortality in Korogocho and Viwandani in the years 2003–2005 among the whole population. The injuries that caused mortality among children were not specified, though findings in the overall population were that firearm (23 per cent), road traffic accident (22 per cent), blunt force/trauma (18 per cent) and poisoning including alcohol (15 per cent) were the dominant causes of mortality. Additional findings were that living in Viwandani (OR 3.21, CI: 1.18–8.71) and living in a village with high proportion of single-person households (OR 13.52, CI: 2.76–66.20) increased the risk of dying from an accident (ibid.)

Although not in a LIC, Shinsugi et al. (2015) scrutinized whether injury-induced childhood (0–18 y) mortality was seasonal in Japan. Findings were that in the group IM the dominant causes were suffocation and homicide, which accounted for 57 and 11 per cent of all injury-induced IM respectively. In the CM group, transport accidents (28 per cent), drowning (20 per cent) and suffocation (14 per cent) were the main causes. The only cause that showed a seasonal

variation was drowning, which had a peak during the warm season. However, drowning was most common in the older age children (12–18y) (ibid.). Although this study was in a totally different setting it could give a hint of what injuries might be seasonal. No studies were found looking at injury induced U5M and or seasonality in a LIC.

5.3.4.5. Nutrient deficiency

Caulfield et al. (2004) concluded that moderate to severe undernutrition could be an underlying cause in up to 55 per cent of the most common childhood killers in the African region. When segregating diarrhoea, pneumonia, measles and malaria the authors found that undernutrition could be attributed in 65, 55, 45 and 60 per cent of the cases respectively (ibid).

Fotso et al. (2012) estimated the stunting prevalence among children living in Korogocho and Viwandani slums to be up to 60 per cent, with the worst figures at >16 months. Severe stunting (3SD) appeared to be 25 per cent (ibid.). Similarly, Abuya et al. (2012) estimated the stunting prevalence to 40 per cent, connecting this to maternal education, birth weight and gender. Boy children were more stunted.

Comparably, Olack et al. (2011) estimated in a cross-sectional study, conducted in two villages in the Kibera slum in Nairobi, that 47 per cent of the children living there were stunted and almost twelve per cent were underweight. The older children, 36–47 months old, had the largest proportion of stunting (58 per cent) and the children 6–11 months were more often wasted. Also, findings were that girls were more likely to be wasted than boys.

Findings in slums in India (Ghosh and Shah, 2004) suggested that some of the most common causes of malnutrition there were bad nutritional utilization due to parasites and infections, poor food security and poor environmental conditions. However, this review only included older studies, spanning from 1989–2001. Nevertheless, these results confirm the findings in Nairobi on stunting and parasite prevalence in children and also the poverty linkage (Fotso et al., 2012; Mbae et al., 2013; Olack et al., 2011).

Breastfeeding in environments with poor water and hygiene quality has been shown to have a large protective effect on child diarrhoeal morbidity and mortality (Ahiadeke, 2000). Estimations of breastfeeding practices in Korogocho and Viwandani are that 99 per cent of the children had ever been breastfed. However, 40 per cent of the children were given something else than mother's milk to drink within the first week and only two per cent were exclusively breastfed for the recommended six months (Kimani-Murage et al., 2011). Kimani-Murage et al. (2015) found through focus-group interviews in Korogocho and Viwandani that factors affecting mothers decision to breast feed their child were: poverty, living conditions, single motherhood, poor knowledge and support and having a HIV-infection.

Olack et al. (2011) described a period of food insecurity in early 2008, with violence, rising food prices and food shortage as a result of the general election in December 2007. However, wasting in children living in the slums did not increase (ibid.) even though slum inhabitants applied negative coping strategies, e.g. reducing the number of meals and food variety to conquer the crisis (Kimani-Murage et al., 2014). The overall food security under 'normal' conditions in Korogocho and Viwandani was, in 2011–2012, estimated to be 'insecure' in up to 85 per cent and 'severely insecure' in 50 per cent. Furthermore, the situation seemed to be even worse in Korogocho than in Viwandani (ibid.).

Crises like the one described might have affected the morbidity and/or mortality rates in the following years, with bad nutritional status contributing to adverse health outcomes. However, when comparing the yearly fluctuation in **Figures 3–7**, nothing extraordinary was visible.

5.3.5. Mortality

The factors in the framework (**Figure 1**) determining the final outcome variable (*mortality*), i.e. access to treatment and/or prevention, are discussed below.

5.3.5.1. Treatment and prevention

WHO (2012) estimated measles to cause five per cent of the annual global U5M in 2010 and 36 per cent of the measles deaths occurred in SSA. Comparably, measles was found to be one of the top ten killers among under-five children in Korogocho and Viwandani slums in 2003 and 2005

(Kyobutungi et al., 2008), assumingly contributing to the diarrhoeal deaths profoundly (UNICEF and WHO, 2009). Mutua et al. (2011) compared vaccination recommendations from the WHO with vaccination cards of children in Nairobi slums. They found that the overall coverage was high, e.g. diphtheria, tetanus and pertussis coverage appeared to be 97 per cent. Nevertheless, vaccination coverage of measles and polio was only 62 and 57 per cent respectively.

Studies show that in Viwandani and Korogocho, the main predictors for seeking health care for ill children outside the home were: ethnicity, available finances, being the only child, having a mother with any formal education that was working, the father being alive and the perceived severity of the illness. The youngest children, 0–11 months, were more often taken to health care facilities, whilst the older children (49–59 months) were less likely to be taken to seek health care. Diarrhoeal symptoms were more often sought for than respiratory symptoms and private clinics and drug shops were the most common institutions for health care seeking. No difference between genders were shown (Ndugwa and Zulu, 2008; Taffa and Chepngeno, 2005).

In the study population, NM accounted for 23 per cent of the total U5M and out of these deaths, 80 per cent occurred in the first week of life. Maternal health is a vast contributor to neonatal survival (Lawn et al., 2005). Comparable to the study results, most neonatal deaths globally occur during the first week after birth, the majority on the first day, from asphyxia as a consequence of obstructive labour (ibid.). In 2008 more than three-quarters of the global third-trimester stillbirths were estimated to occur in SA and SSA. Half of these took place after labour had begun, in the intrapartum phase (ibid.). Consequently, lack of sufficient antenatal care [ANC] and intrapartum care were found to be principal reasons for mothers and children not surviving the delivery (ibid.).

Meeting the need for family planning, abortions, sufficient ANC visits and skilled birth attendance are important preventative measures for pregnancy related morbidity and mortality (Ronsmans et al., 2006). Ziraba et al. (2009) estimated that in Korogocho and Viwandani, in the years 2003 to 2005, the maternal mortality ratio, i.e. women dying from pregnancy related outcomes per 100,000 live births, was 706. In Kenya overall the same ratio was 560. The main

reasons for maternal mortality in the slums were found to be abortion complications, haemorrhage, sepsis, eclampsia and ruptured uterus as a consequence of obstructed labour (ibid.).

Fotso et al. (2009b) found that in 2004 to 2005 in Korogocho and Viwandani, 70 per cent of childbirths actually took place in a health facility. Nonetheless, only 48 per cent of deliveries were in a facility considered being at a minimum standard, e.g. had emergency obstetric care, could administer oxytocin and could preform assisted vaginal delivery. Factors found to affect where a delivery would take place were education, parity, household wealth, advise during ANC and whether the child was wanted or not. Advise during ANC seemed to be most effective among the poorer women. Fotso et al. (2009a) state that 97 per cent of women living in Korogocho and Viwandani in 2006 attended at least one ANC visit. However, the proportion of women who attended ANC in the first trimester as recommended, was only 7 per cent and 48 per cent had less than the recommended four visits.

5.4. Summary of discussion

Displayed in **Table 7** is a summary of the discussed factors in the applied theoretical framework, presenting if and how these were found to be seasonally affected, when reviewing the literature from similar settings, potentially affecting the mortality outcome in the results. Also displayed, is what factors were found to be affected by the rainy and cold season, as this was the season when the peaks of mortality showed in the analysed data.

Table 7. Summary of discussion. How factors in the applied theoretical framework were found to be seasonally affected, according to literature from similar settings.		
Factor in theoretical framework:	Seasonally affected	Rainy / cold season
Maternal socio-economic status	No	-
Environmental Contamination	Yes	Yes
<i>WASH</i>	Yes	Yes
<i>Housing quality and overcrowding</i>	No	-
Ill-health	Yes	Yes
<i>Respiratory infections</i>	Yes	Yes
<i>Diarrhoeal disease</i>	Yes/No	Yes/No
<i>Vector borne disease</i>	Yes	Yes
<i>Injuries</i>	Yes	No
<i>Nutrient deficiency</i>	No	-
Mortality	Yes	Yes
<i>Age and gender</i>	No	-
<i>Treatment and prevention</i>	No	-

6. Conclusion

Neonatal, post-neonatal, child and under-five mortality all seemed to display a seasonal pattern corresponding to the yearly fluctuation of temperature and precipitation, with a predominant intensification in the wettest and coldest months. Child mortality seemed to be the only group

with increased mortality also in the second rain period, not reflected in the overall mortality index. When scrutinizing the web of factors leading up to the most common causes of child mortality and their probability of seasonal variance, the seasonal peak-patterns of overall under-five mortality could be more systematically be explained.

The findings in this study emphasise the importance of disaggregating data when looking at seasonal events of mortality and not solely relying on analysis of compiled data, as such may lose variances between age and gender groups. The findings in this thesis could be used to set the agenda for preventative interventions aimed at reducing childhood morbidity and mortality, concentrating interventions more timely on different child age groups, throughout the season.

More studies are needed to determine the linkage, and to statistically associate weather and environmental data with causes of mortality in different age and gender groups. This so that preventative resources can be confidently aimed at the right child age group and adequately in time. Future studies should include more years in the analysis, in order to validate the findings in the mortality groups with fewer events, e.g. neonatal and child mortality.

7. Acknowledgements

I would like to express my sincere appreciations to the APHRC and its funders¹ for initiating the NUHDSS and for enabling the external use of microdata, providing an important source of rare information.

A special thanks to my supervisors at Uppsala University, Carina Källestål and Katarina Ekholm Selling and to my student colleagues Josefine, Karin, Lisa and Sabine for the good advice, support and comfort when writing up this thesis.

Lastly, I would like to thank my closest family, Noor, Ayo and Erik, who have stood by me on this journey. Mycket kärlek!

¹ Rockefeller Foundation (USA), the Wellcome Trust (UK), the William and Flora Hewlett Foundation (USA), Comic Relief (UK), the Swedish International Development Cooperation (SIDA) and the Bill and Melinda Gates Foundation (USA)

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9. Annex

9.1. Figures: Seasonal patterns

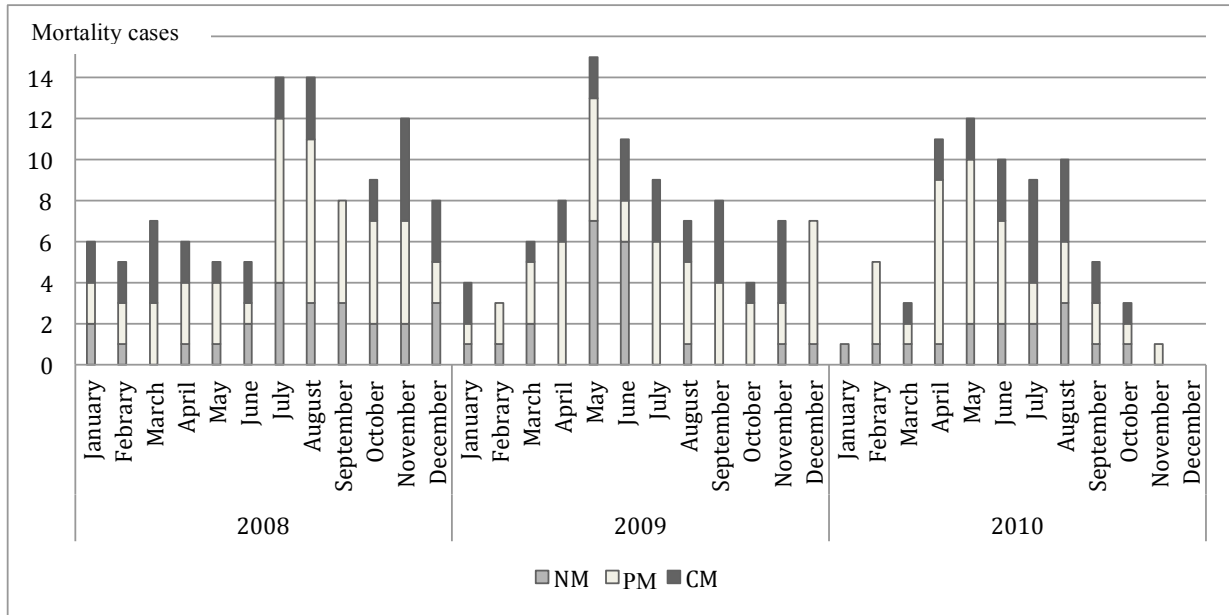


Figure 10. Distribution of under-five mortality segregated by neonatal, post-neonatal and child mortality, in Korogocho and Viwandani urban slums in Nairobi, Kenya 2008–2010. N=258.

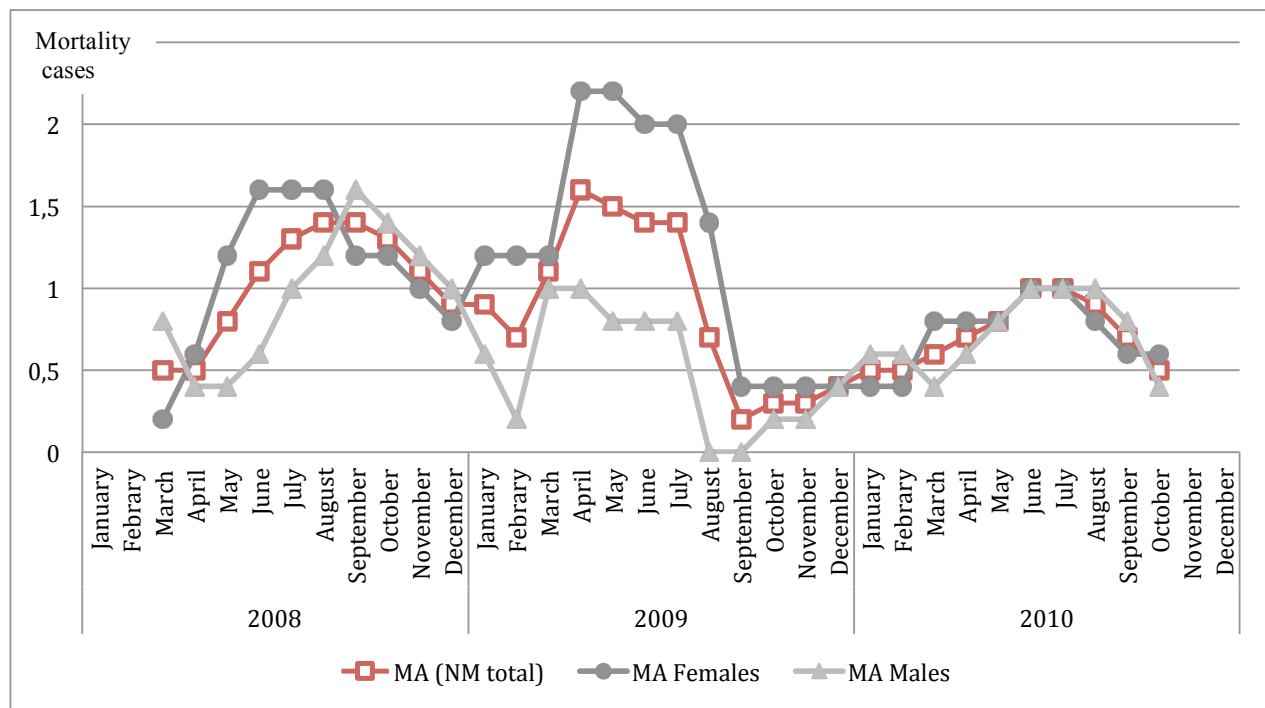


Figure 17. Moving average of neonatal mortality over time stratified by gender in Korogocho and Viwandani urban settlements in Nairobi, Kenya 2008–2010. N=59 (female=34, male=25).

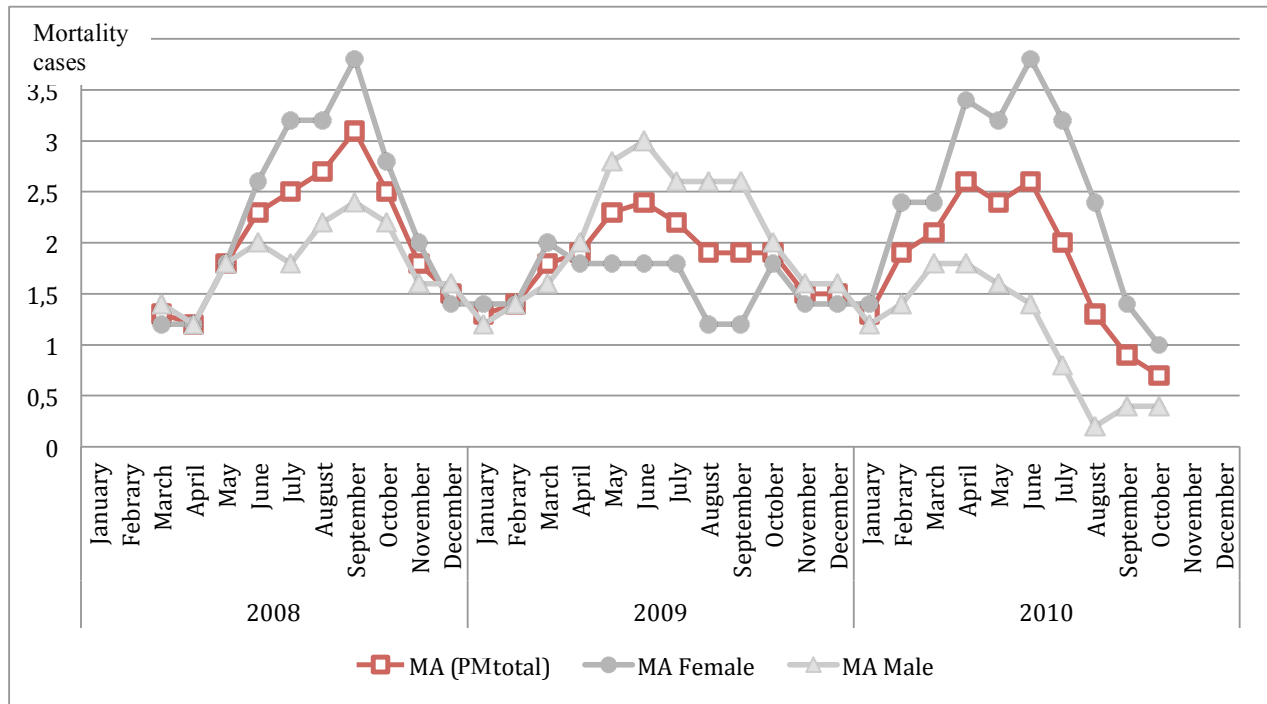


Figure 18. Moving average of post-neonatal mortality over time stratified by gender in Korogocho and Viwandani urban settlements in Nairobi, Kenya 2008–2010. N=127 (female=69, male=58).

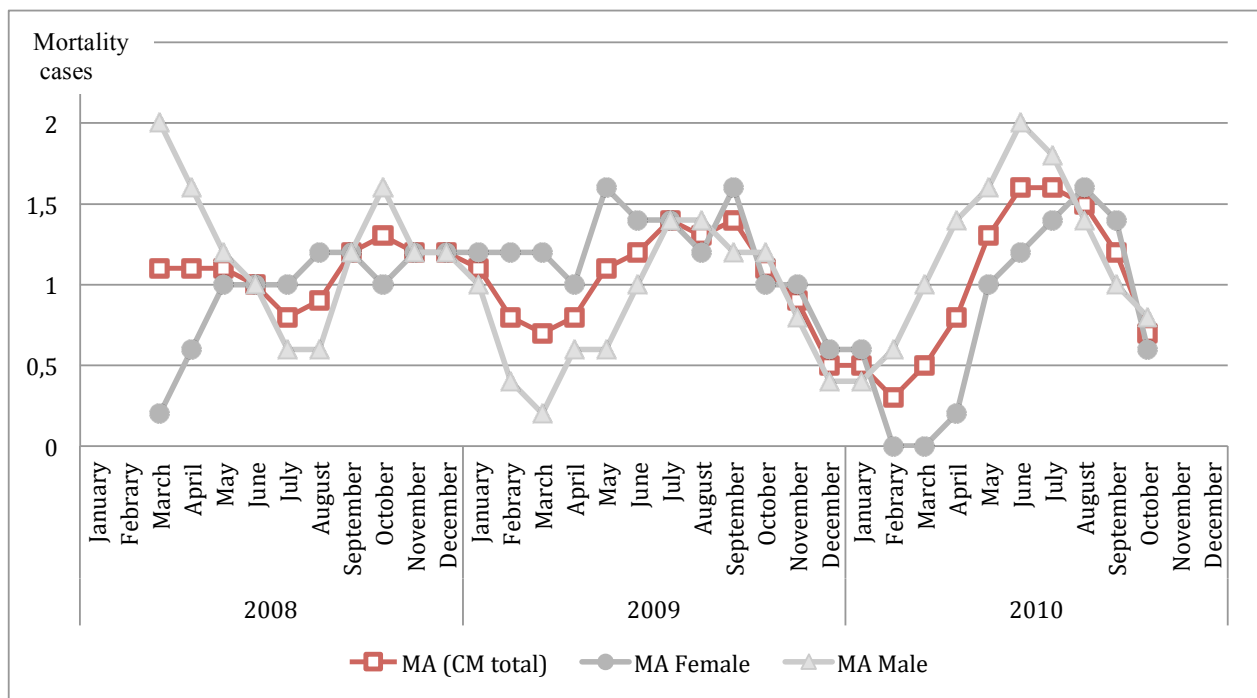


Figure 19. Moving average of child mortality over time stratified by gender in Korogocho and Viwandani urban settlements in Nairobi, Kenya 2008–2010. N=72 (female=33, male=39).

9.2. Tables: Decomposed seasonal factor

Table 3. Decomposed seasonal factorial attribute¹ (S_t) on mortality by mortality groups and month, 2008–2010 in Korogocho and Viwandani slums, Nairobi, Kenya. N=258.

Month	U5M n=258	NM n=59	PM n=127	CM n=72
January	0.41	0.78	0.19	0.45
February	0.72	0.86	0.88	0.00
March	0.84	0.58	0.74	0.86
April	1.11	0.57	1.46	1.25
May	1.18	1.40	1.27	0.84
June	0.88	1.35	0.53	1.09
July	1.13	0.85	1.15	1.29
August	1.22	1.15	1.23	1.26
September	0.91	0.60	0.99	0.75
October	0.76	0.59	0.83	0.65
November	1.38	1.29	1.03	2.15
December	1.28	1.46	1.33	0.63

¹ Moving average = 1.00

Table 5. Decomposed seasonal factorial attribute¹ (S_t) on mortality by gender, mortality groups and month, 2008–2010 in Korogocho and Viwandani slums, Nairobi, Kenya. N=258.

Month	U5M (n=258)		NM (n=59)		PM (n=127)		CM (n=72)	
	Females (n=136)	Males (n=122)	Females (n=34)	Males (n=25)	Females (n=69)	Males (n=58)	Females (n=33)	Males (n=39)
January	0.73	0.00	1.67	0.00	0.36	0.00	0.83	0.00
February	0.67	0.88	0.00	3.33	0.98	0.71	0.00	0.00
March	0.80	0.65	0.56	0.83	0.61	0.87	1.94	0.83
April	1.07	1.13	0.97	0.00	1.32	1.61	0.67	0.89
May	0.98	1.43	1.29	2.50	1.34	1.38	0.21	1.25
June	1.09	0.60	1.75	0.33	0.44	0.39	1.18	1.00
July	1.19	0.94	0.63	1.00	0.91	1.20	2.33	0.19
August	1.05	1.46	1.07	0.94	1.49	0.71	0.49	2.30
September	1.18	0.62	0.83	0.42	1.66	0.27	0.65	0.89
October	0.50	1.17	0.56	0.48	0.24	1.79	0.89	0.49
November	1.31	1.45	1.25	0.83	0.75	1.25	2.33	1.88
December	1.42	1.15	1.88	1.25	1.43	1.25	0.42	0.83

¹ Moving average = 1.00