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ESTIMATING CHILDHOOD MORTALITY IN GHANA: DOES USING DIRECT OR INDIRECT METHODS MATTER?

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BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:.. Date:..........................

Name: Kwamena Sekyi Dickson

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature:.................................. Date:........................

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ABSTRACT

There are essentially two main methods for estimating demographic indices, namely direct and indirect methods. The direct approach for estimation works well with reliable, timely, and adequate data. The lack of dependable data as a result of the poor functioning of vital registration systems and poor reporting of events in surveys in developing countries had spawned indirect approaches. Using data from the 2014 Ghana Demographic and Health Survey (GDHS), the study sought to compare childhood mortality estimates using direct and indirect methods. The MORTPAK software version 4.3 and STATA version 14 were used to analyse the data. The direct estimations were done using STATA version 14 and the indirect estimations were carried out using the QFIVE application based on MORTPAK software version 4.3. There were variations in estimations from direct and indirect methods. The results showed that under-five and infant mortality were higher, using both indirect and direct techniques for males compared to females. Estimations from indirect methods were higher than those from direct estimations. The Palloni-Heligman version of the Brass method should be used to estimate infant and under-five mortalities in Ghana. This can help fill the gap of under-reporting of infant and under-five mortality.

KEY WORDS

Demographic

Direct

Estimation

Indicators

Indirect

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DEDICATION

To my family

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LIST OF ABBREVIATIONS

DANIDA	Danish Development Agency
DHS	Demographic and Health Survey
GAC	Ghana Aids Commission
GDHS	Ghana Demographic and Health Survey
GHS	Ghana Health Service
GSS	Ghana Statistical Service
ILO	International Labour Organisation
MDG	Millennium Development Goals
SDG	Sustainable Development Goals
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION

Background of the Study

There are essentially two main methods for estimating demographic indices, namely direct and indirect methods (Croft et al., 2018; Moultrie et al., 2013). The direct approach for estimation works well with reliable, timely, and adequate data (Hill, 2013; Moultrie et al., 2013). The sources of data for this approach are vital registration, surveys, and census. The direct approach works best with data from vital registration. The lack of dependable data (as a result of poor functioning of the vital registration system and poor reporting of events in surveys in developing countries) has spawned indirect approaches (Preston et al., 2001). The indirect approach uses mathematical functions and model life tables to estimate demographic rates.

The use of a direct approach foregrounds the need for accurate and reliable demographic data for analysis and planning. In relation to this, two arguments have emerged. The first is that bad data is worse than no data. The other view is that bad data is better than no data. According to advocates of the former, the use of bad data affects the accuracy of estimates based on such data (Moultrie et al., 2013). For the latter, bad data could be massaged to provide estimates for a country or group which is characterised by inadequate data in terms of quality and quantity (Moultrie et al., 2013). Challenged by this situation, indirect approaches have been developed to utilise the inadequate and unreliable data in African counties to estimate demographic indicators (Preston et al., 2001).

For the estimation of mortality indicators, the indirect methods which have emerged are the Brass Logit Systems (Brass & Coale, 1968), Coale-Demeny model life tables, Lederman Model life table system, United Nations model life tables for developing countries, and the INDEPTH Model life tables for sub-Saharan Africa (INDEPTH Network, 2004; Murray et al., 2000; Preston et al., 2001). The basis of the mortality estimates is the use of life tables.

Brass Logit System assumes that two age groups differ – the mortality patterns may be related linearly varying the logit of the respective chances of survival (INDEPTH Network, 2004). The Brass logit system uses mathematical functions and standard life tables to express the association between population and standard mortality patterns. The issues were broadened by Trussell, Palloni-Heligman, and others. For instance, the Trussell variant builds on the life tables developed by Coale-Demeny (Trussell, 1975), while the Palloni-Heligman version was based on the model life table of the United Nations for developing countries. (United Nations Department of International Economics, 1990).

Model life tables present the most comprehensive description of a population’s mortality (Murray, Ahmad, & Salomon, 2000). These summarise the age-specific mortality rates to be used to forecast human survival (INDEPTH Network, 2004). The model life tables were based on evidence about the fading out of a birth cohort (Preston, Heuveline, & Guillot, 2001). The risk of dying is estimated using mathematical functions to designate the dissimilarities in mortality concerning age (Preston, Heuveline, & Guillot, 2001).

The Coale-Demeny Model life tables, developed in 1966, were constructed from 192 empirical life tables from Europe, Africa, Australia, Asia, North America, Israel, and New Zealand. From the list, four mortality patterns were derived and named East, North, South, and West models (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004).

The Lederman model life table system was introduced in 1969 and derived from factor analysis of 157 empirical life tables (INDEPTH Network, 2004). This model used five factors to explain the level of variance between the life table. These were overall mortality rate, the association between child and adult mortality, adult mortality, child mortality under five years, and the mortality gap between men and women from 5 to 70 years (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004).

In 1982, for developing countries, the United Nations developed model life tables principally to address the conditions existing in the developing countries, which the two previous model life tables were unable to address. Five models were constructed to cover South Asia, Latin American, Far Eastern, Chilean, and General (INDEPTH Network, 2004).

The INDEPTH Network life tables were published in 2004 based on data from demographic surveillance sites established in sub-Saharan Africa and some areas in Asia with the objective of filling in the data source gaps generally lacking in developing countries. Two patterns were identified based on the low prevalence of HIV and AIDS and areas affected by HIV and AIDS (INDEPTH Network, 2004).

In 1983, the division of International Economic and Social Affairs of the United Nations put together the available life tables and indirect methods in a document that became known as Manual X (10) to help demographers carry out demographic estimations for areas with limited data. The Manual became a guide and framework for carrying out estimations, using incomplete and unreliable demographic data (Department of International Economic and Social Affairs, 1983).

In the early 1990s, the United Nations developed a step-by-step guide for the estimation of child mortality, based on the principle of Manual X. An application called QFIVE was developed by the population division of the United Nations (United Nations Population Division, 2003) based on the principles of the Brass method for estimations. This QFIVE application uses the Palloni-Heligman and Trussell variants of the Brass method (United Nations Department of International Economics, 1990).

Moultrie and colleagues were commissioned in 2013 by the United Nations Population Fund (UNFPA), with backing from the International Union for the Scientific Study of Population (IUSSP), to review and revise the indirect methods of demographic estimations published in the 1980s by the United Nations. They came out with the tools for demographic estimations which is an update of Manual X developed by the United Nations. The tools were to serve as a guide for estimating demographic indicators from incomplete and inaccurate data (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013). The demographic estimation tools have upgraded version of Manual X and included two other manuals which were produced after the development of Manual X, for estimating demographic parameters from data from censuses (UN Population Division, 2002), and approaches for assessing adult mortality (Sloggett, et al., 1994).

One of the challenges of the demography of sub-Saharan Africa is the lack of adequate and reliable data hence the attempt to develop indirect estimation techniques (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013)

Sources of Demographic Data

There are four sources of data for calculating or estimating demographic indicators. These are vital registration systems, censuses, surveys, and population registers (Siegel & Swanson, 2008). Vital registration system entails the continuous compilation, collecting, and legal registering and publicising statistics relating to vital events such as live births, deaths, adoptions, marriages, separations, and annulments of marriages and divorces in a population (Hill, 2013; Siegel & Swanson, 2008; United Nations, 2014). Although there has been a substantial improvement in the vital registration systems of most developing and low-income countries, there still exists the problem of inaccurate and incomplete demographic data (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013).

The census is the overall process of preparing, gathering, compiling, reviewing, disseminating and analyzing, at the lowest geographical level, demographic, economic and social data for all persons in a country or a well-delimited part of a country at a defined time (Siegel & Swanson, 2008; United Nations, 2017; United Nations, 2008). Census data entails the compilation of economic, demographic, and social data relating to all persons in a well-defined area or a country at a specified time.

A survey is a systematic means of gathering information from units to generate quantitative descriptions of the large population attributes to which the units belong (Groves et al., 2009). Survey data may include a collection of data on mortality, fertility, and migration of a sample population.

The population register refers to a system that provides continuous tracking of selected information on incidents that occur to all in the population to provide up-to-date population size and composition information at a given time frame (United Nations, 2015). Population registers are collected from the population's basic records and their characteristics in an area, continuously replaced by data on births, deaths, marriages, adoptions, divorces, rights and changes of occupation, name, or address. (Siegel & Swanson, 2008). Population register is often awfully expensive to maintain and is usually effective in countries with a high literacy rate. They are mostly not effective in developing countries (Nsowah - Nuamah, 2007; Siegel & Swanson, 2008).

These data sources are used to determine the population size and composition at a particular point in time and also for estimating demographic rates such as birth and death. This helps in the planning, monitoring, and evaluation of maternal and child health services that are carried out on the basis of the availability of live birth records and child and maternal death records (United Nations, 2015).

In countries that have complete and reliable data, the vital registration system conventionally becomes the best source of data for demographic estimations, whereas those without reliable and accurate data, like most sub-Saharan African countries, rely on data from census and surveys to estimate demographic indicators. Direct methods work well with complete and accurate data from vital registration; however, the indirect methods approach is appropriate when the data available is incomplete or limited and rely on data sources from census and surveys (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013).

Statement of the Problem

The vital registration system of Ghana does not provide reliable data for demographic estimation (Births and Deaths Registry, 2014) due to underreporting, misreporting, and omission of births and deaths. In 2012, 60 percent of all births and 21 percent of all deaths were reported to be registered (Births and Deaths Registry, 2014). The registration of death is worse when it comes to children. Death among children varies by classification and age of death (Births and Deaths Registry, 2014).

These challenges with vital registration data have led to the over-dependence on survey and census data to fill the gaps of inadequate data. Nationwide surveys such as the Ghana Demographic and Health Survey, the Ghana Maternal Health Survey, and the Ghana Multiple Indicator Cluster Survey report on full birth history, which give information on births and deaths among children in the country.

However, retrospective data from both full birth history and summary birth history suffer from some limitations (Woodruff, 2002) such as recall biases and given socially acceptable responses. Due to the inadequate and unreliable data from vital registration, Ghana has had to rely mainly on censuses or nationally representative surveys such as the Demographic and Health Survey, and Maternal Health Survey data to estimate mortality and fertility indicators and by applying direct methods for some of the estimations.

Conventionally, direct methods are used for data from vital registration where the data is accurate and complete. Applying direct methods on data from surveys may come with some challenges such as underestimations of demographic indicators. For instance, it is reported that infant and under-five mortality rates from the 2014 Demographic and Health Survey were underreported (Ghana Statistical Service (GSS), Ghana Health Service (GHS) and ICF International, 2015). This may be because of recall bias since women are asked questions about their birth history within the last five years.

Studies on techniques of estimating under-five mortality have focused on the assessment of full birth history and summary birth histories in child mortality estimation (Verhust, 2016; Pedersen & Liu, 2012; Silva, 2012) and the violations of assumptions of these methods (Adetunji, 1996).

Available evidence suggests that there is no optimal method for estimation for all situations, for instance, the use of direct methods for calculating under-five mortality based on survey data. The question one may ask is whether in the estimation of infant and under-five mortality, the method of estimation matters? This study applies both direct and indirect methods to estimate infant and under-five mortality in Ghana, using data from the 2014 Ghana Demographic and Health Survey (GDHS).

The study sought to examine both the direct and indirect methods approach for the estimation of demographic indicators, by applying the direct and indirect methods to estimate infant and under-five mortality. The study then compared whether there are differences in the results derived using the direct and indirect methods. The essence was to explore the possibility of using indirect methods to estimate demographic indicators from survey data. The two indirect methods used are the Trussell and Palloni-Heligman variants of the Brass Model. The Trussell and Palloni-Heligman variants of the Brass Model was selected because it uses both mathematical functions and model life tables in its estimations of childhood mortality unlike the other models which use either mathematical functions or a model life table for estimations of childhood mortality.

Objectives of the Study

The main objective of the study is to examine direct and indirect methods for estimating demographic indicators for Ghana using childhood mortality data. Specifically, the objectives of the study are to:

1. Estimate childhood mortality using direct methods.
2. Estimate childhood mortality using indirect methods.
3. Test if there are statistically significant differences between the direct and indirect estimates.

Hypotheses of the Study

The following hypotheses were tested in furtherance of the above objectives:

1. H_0: There is no significant difference between the results of Direct and Trussell techniques for infant mortality.
2. H_0: There is no significant difference between the results of Direct and Palloni-Heligman techniques for infant mortality.
3. H_0: There is no significant difference between the results of Direct and Trussell techniques for under-five mortality.
4. H_0: There is no significant difference between the results of Direct and Palloni-Heligman techniques for under-five mortality.

Significance of the Study

Since the 1950s methods of estimating basic demographic measures have received the attention of the global community. Interest in methods of demographic estimations stems from several factors. Firstly, demographic indicators serve as the basis for projection and planning purposes. Using a wrong estimate may affect decisions on planning and development.

Secondly, the choice of method of estimation is dependent on the availability and completeness of data. This is also reliant on the source of data. For instance, most developing countries do not have reliable vital registration systems and have to depend on data from surveys and censuses. Hence the need for robust indirect estimation techniques.

It is envisaged that findings from this study will provide insight into the prevailing discourse on the use of direct and indirect methods to estimate demographic indicators for countries such as Ghana. It would also serve as the basis for further research on approaches to estimating childhood mortality indicators.

Organisation of the Study

The study is organised in seven chapters. Chapter One is the introduction and describes the background to the study, statement of the problem, objectives of the study, the significance of the study, and the organisation of the study. The approaches for estimating under-five mortality and the analytical models are reviewed in Chapter Two.

Chapter Three focuses on the sources of data and methods of analysis of the study. Among the issues covered are the source of data (acquisition of data, sampling and sampling procedure, definition, and description of variables), management, processing, and data analysis.

Chapter Four captures the estimation of under-five mortality using direct methods. This section covers the estimations of infant mortality and under-five mortality using survey data. Chapter Five discusses the estimation of infant mortality using indirect methods. Among issues covered are estimations of infant mortality using two types of indirect methods of estimation (the Trussell and Palloni-Heligman versions of the Brass method) and comparing the results with that from direct methods.

Chapter Six estimates under-five mortality using the Trussell and Palloni-Heligman indirect methods and compares the results in the estimations using direct methods. The last chapter, Chapter Seven, is devoted to the summary of the main findings, conclusions, recommendations, and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Interest in demographic estimation has increased since the first attempt by John Graunt in the calculation of mortality from parish registers in London (Yusuf, Martins, & Swanson, 2014). This chapter reviews the direct and indirect techniques for estimating demographic indicators. The indirect approaches for estimating demographic indicators with emphasis on infant and under-five mortality include United Nations model life tables, Coale and Demeny regional model life tables, Lederman model life tables system, United Nations model life tables for developing countries, INDEPTH model life table for sub–Saharan Africa, and the Brass methods.

Concepts of Demographic Analysis

Demography emanates from two Greek words: "Demos," meaning people and "Graphos," meaning to write. Demography studies population change and structure (Hinde, 1998). The United Nations defined demography as the "scientific study of human populations, primarily, concerning their size, their structure, and their development" (United Nations, 1958 pg 21).

Demography focuses on the human population, including population size, distribution, composition, components of population dynamics, and socioeconomic determinants and consequences of population change (Swanson & Siegel, 2008). Population size refers to the number of persons in a given area at a particular point in time (Yusuf, Martins, & Swanson, 2014). The population size increases with birth and immigration and declines through death and emigration.

Population distribution refers to how dispersed the population is in a given geographical area at a particular point in time. This is the arrangement of a given population in space (Nsowah-Nuamah, 2007; Swanson & Siegel, 2008). Population composition refers to the number of persons, in age, sex, and other demographic characteristics. There are two types of characteristics namely ascribed and achieved. The ascribed characteristics are characteristics that will never change, such as age, sex, race, year of birth, and place of birth. Achieved characteristics change over time, such as level of education, wealth status, living arrangements, and marital status (Swanson & Siegel, 2008; Yusuf, Martins, & Swanson, 2014).

There are three main components of population change, namely migration, fertility, and mortality. Migration is the movement of people from one place to live in another. This may also refer to a permanent change in place of residence this implies moving across geographical and administrative frontiers. Migration can be international or internal. Internal migration occurs within a country and international migration occurs outside a country. Migration can be voluntary or forced (Weeks, 2020). Generally, there is a distinction between short-term or temporary migration, involving movements with a period between three and 12 months, and long-term or permanent migration, referring to a change of country of residence or having the intension of staying for a duration of one year or more (Demopadia, 2013). Seasonal and periodic movement and vacations are not termed as migration.

Fertility is the actual birth performance of an individual or a couple and is affected by intermediate variables such as proportions married, contraception, induced abortion, lactational infecundability, frequency of intercourse, sterility, spontaneous intrauterine, and duration of fertility period. In the estimation of fertility only live births are counted (Yusuf, Martins, & Swanson, 2014; Bongarts, 1978). Life birth may be referred to the complete extraction of a product of conception from its mother regardless of the length of pregnancy which shows proof of life such as heat beating, breating and movement of voluntary muslse (Demopadia, 2013; Siegel & Swanson, 2008)

Mortality is the perpetual disappearance of all evidence of life at any time after live birth has taken place (United Nations, 2017). Infant mortality is the probability of a newborn baby dying before their first birthday. Under-five mortality is the probability of a newborn baby dying between birth and exactly five years. It is normally expressed per 1,000 live births (United Nations Inter-Agency Group for Child Mortality Estimation [UNIGME], 2017; Ghana Statistical Service [GSS], Ghana Health Service [GHS], and ICF International, 2015).

Approaches for Estimating Demographic Indicators

There are basically two estimation approaches for deriving demographic estimates, namely direct and indirect methods.

Direct Estimation

Direct estimations are demographic estimations that are calculated using vital registrations, census, and specialised surveys that are accurate and reliable (Moultrie, Dorrington, Hill, Timaeus, & Zaba, 2013; Siegel & Swanson, 2008).

Direct estimations require data on the date of birth of the child born alive, sex of the child, date of death, i.e., month and year of death of each child. Direct estimations can use data on full birth histories from surveys. Full birth history entails information including the date of birth, sex of the child, survival status, and age at death (if dead). All this information is collected for children ever born from women in a specified age group.

Direct estimations are based on the assumption that there is available accurate, reliable, and timely data, and there is no relationship between mortality risks of children and survival rates of mothers (whether as a result of mortality or migration) in the population (Hill, 2013).

Direct methods can suffer from errors in data such as the omission of deceased children. Furthermore, estimations of infant mortality using direct methods depend on the correct reporting of age at death as over or under one year (Croft, Trevor, Aileen, Courtney, & al., 2018). Misreporting of birth dates can affect direct estimates and infant mortality may be underestimated.

Indirect Estimation

Conventionally, demographic estimation is grounded on data resulting from a vital registration system or a census. Presuming that both vital registration and census are faultless and complete, demographic estimation would have been calculated directly from available data. Unfortunately, vital registration systems of most developing countries have not been able to record vital proceedings such as births and deaths as they occur and data is not reliable (Preston, Heuveline, & Guillot, 2001).

Indirect estimations methods were inspired by the lack of reliable data especially in developing countries (Preston, Heuveline, & Guillot, 2001). It uses minimum data available such as birth history to estimate demographic indicators. For instance, a brief history of births which is the cumulative information on the number of children ever born and the number of children survived by women in a certain age group (or in another group or spousal duration since birth) (Hill, 2013) can be used to derive mortality experience of children. Birth history summary can be performed separately for male and female children because their mortality patterns differ. The chances of survival are different for males and females during early childhood (Sawyer, 2012).

The death rate of children under five years reflects the proportion of deaths of children ever born to women of a certain age group (or the duration of marriage or the time since the first birth). It is also influenced by the age pattern of deaths of children below five and the age of mothers (Hill, 2013). Children from younger and older mothers are more at risk of death than those in the mid-range 20 – 39 years (Myrskylä & Fenelon, 2012).

Indirect estimations require data on the number of children ever born alive by women by five-year groupings, number of women, grouped by five-year age, or time since first birth or duration of marriage, number of children surviving before the survey by women five-year grouping and the number of births in a period before the survey by women five-year grouping.

Indirect estimates are based on five key assumptions. First, the age patterns of the population in terms of mortality and fertility of children under five are sufficiently embodied by the model properties used in method development. Second, child mortality never changes in a group of five mothers. Third, there is no link between child mortality risks and maternal survival (not as a result of death or migration) in the population. Fourth, changes in infant mortality in the recent past have been gradual and unidirectional. Finally, the average number of children born according to age adequately reflects well-defined cohort patterns of children (Hill, 2013). However, the assumptions of independence between the death of a child and the mother may be violated in the context of HIV and AIDS, where there is vertical transmission of the virus from mother to child. This has resulted in the revision of the methods to take account of these changes (Moultire et. al., 2013).

Indirect methods of estimation can suffer when women do not know their ages or the age of their first child, as common in many less-developed countries, which introduces some biases to the classification of death. These biases are higher if age is estimated based on characteristics linked directly or indirectly to mortality levels, for instance, the number of children ever born (Croft, Trevor, Aileen, Courtney, & al., 2018; Woodruff, 2002). Violations of the assumption of indirect methods also commonly occur and the indirect methods assume that the births of a cohort of women represent the children born in a period (Woodruff, 2002).

Usually, indirect techniques of estimations are used to estimate under-five mortalities, which is infant and child mortality. Under-five mortality is the probability of a newborn baby dying between birth and exactly five years. It is normally expressed per 1,000 live births (United Nations Inter-agency Group for Child Mortality Estimation (UNIGME), 2017). Childhood mortality serves as a key indicator of a country's socio-economic expansion and the eminence of life as well as its wellbeing (Crombie, Irvine, Elliott, Wallace, & World Health Organization, 2005; United Nations Inter-agency Group for Child Mortality Estimation [UNIGME], 2017).

United Nations Model Life Tables

In the 1950s, the United Nations Population Division developed a series of lifelong models. This was based on data from 158 life tables observed in age-specific mortality (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004). It is derived from the assumption that the probability of dying nqx is a quadratic function of the previous q value, i.e. 5qx-5. The probability of dying before age 1 is denoted by the symbol 1q0 while the probability of dying between age 1 and before age 5 is expressed as 4q1. In five age groupings, the symbol is 5qx (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004).

The United Nations model life table is a one-parameter system, which means that by knowing one mortality parameter ($_1q_0$) one would be able to determine a complete life table (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004).

The quadratic equation coefficient was estimated by running a regression analysis on the 158 empirical mortality data for combined sexes, males, and females. The actual model life tables were calculated based on the coefficients, by first selecting, randomly, a suitable value of 1q0 which would be replaced in the equation involving $_1q_0$ to $_4q_1$ to attain a value for $_4q_1$. After this, it was substituted in the equation involving $_5q_5$ to $_4q_1$ to generate $_5q_5$ and subsequently others (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004; Murray et al., 2000). This chain of process continued until the United Nations model life tables were completed.

The United Nations model life table has been critised for the lack of flexibility. Some of the 158 life tables that were used to derive the models were not very accurate at the young and old ages (Department of International Economic and Social Affairs, 1983). The United Nations model has also been critised that the 158 empirical life tables do not represent the entire world and the quality of the empirical life tables was poorly assessed since tables from developing countries had numerous deficiencies (Preston et al., 2001).

Coale-Demeny Regional Model Life Tables

The Coale and Demeny regional model life tables, first published in 1966, used empirical life tables to develop a model life table system (Coale & Demeny, 1983; Coale, Demeny, & Vaughan, 1983). All the 192 selected life tables were derived from registration data which were subjected to strict standards of accuracy (INDEPTH Network, 2004). A total of 176 tables were selected from New Zealand, Australia, North American, and Europe. Israel contributed three; Japan contributed six; Taiwan contributed three, and the White population from South Africa contributed four (INDEPTH Network, 2004; Murray et al., 2000).

The Coale and Demeny model life tables consist of four mortality patterns, namely, North, South, East, and West mortality patterns. The North model was based on 9 life tables from Sweden, Iceland, and Norway. It is characterised by low infant mortality, high child mortality, and low old-age mortality beyond age 50. Life expectancy ranges from 44.4 years to 74.7 years (Murray et al., 2000; United Nation Department of International Economics, 1990).

The South model was derived from 23 life tables from Italy, Spain, Portugal, and Sicily. This model is characterised by the high mortality of children under age five, low mortality from about age 40 to age 60, and high mortality over age 65. On the other hand, the East model was based on the 31 life tables from Czechoslovakia, Austria, northern and central Italy, and Germany. The East model has relatively high child mortality rates in infancy and at ages 50 years and above. The life expectancy ranges from 36.6 years to 72.3 years (Murray et al., 2000; United Nation Department of International Economics, 1990).

The West model is based on 128 life tables from South Africa, Canada, western Europe, Australia, Japan, and Austria (Murray et al., 2000; United Nation Department of International Economics, 1990). Life expectancy in these tables ranges from 38.6 years to 75.2 years. The West model lies between the North and East patterns and it is believed to symbolise the most general mortality pattern. In countries with inadequate evidence that prevents a more appropriate selection of a model, the West model becomes the preferred choice (Department of International Economic and Social Affairs, 1983). This is because the West model is derived from the largest number and broadest variety of cases and is believed to represent the most general pattern.

Guidelines for choosing a family of model life table

- A population where breastfeeding is common, mortality in childhood is likely to be well represented by the North family (eg. Ghana)
- In a population with little breastfeeding, a mortality pattern similar to that of the South family may be a good representation of mortality in childhood.
- With a population with low nutritional levels, mortality in childhood is likely to be well represented by the south or the north families.
- With a population where neonatal tetanus is prevalent, the East family may be a good representation of mortality in childhood (eg. India).
- In a population with no empirical information, the West family may be a good representation of mortality in childhood.

Selecting a family should be done deligently because a wrong family of model life table will affect the estimation of demographic indicators. This may either lead to over estimation or under estimation of demographic estimates.

Ledermann Model Life Table System

This model life table system was proposed by Lederman in 1969. Lederman developed a series of parameter model life tables: one-parameter and two-parameter. These model life tables were resultant of regression analysis with 154 empirical life tables (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004; Murray et al., 2000).

The Ledermann models were attained by estimating the probabilities of dying between ages x and x+5 ($_5q_x$) for both sexes, males and females, through logarithmic regression equations. Ledermann's system of model life table is flexible. Unlike the Coale and Demeney life tables and the United Nations model life tables which were based on one independent variable (e_{10} and $_1q_0$, respectively), the Ledermann's models have different sets of regression coefficients for the two equations, each constructed on different independent variable or pair of independent variables (Department of International Economic and Social Affairs, 1983).

The Ledermann models give not only the estimated values of the probabilities of dying but they add the measure of the dispersion of the estimated values that have been observed around the estimated values. This measure of dispersion shows whether there are any inconsistencies between the actual and the estimated, and the magnitude of these inconsistencies (Department of International Economic and Social Affairs, 1983).

In practice, the Ledermann system is not easily applied to developing countries. Most values are not easily estimated with an adequate degree of accuracy so that the introduction of some bias cannot be avoided. Another shortfall of the system is that, when knowledge about the sex differentials about a population is limited, Ledermann models are limited in their use for such population (Department of International Economic and Social Affairs, 1983).

United Nations Model Life Tables for Developing Countries

The United Nations model life tables were developed in 1982 to meet the requirements of developing countries (Department of International Economic and Social Affairs, 1983; INDEPTH Network, 2004). The UN model life table for developing countries was designed based on data from 36 life tables from developing countries. These included nineteen pairs from 11 countries in Asia, one pair in Africa, and sixteen pairs of life tables from 10 countries in Latin America (INDEPTH Network, 2004; United Nation Department of International Economics, 1990).

The United Nations models comprise five patterns of mortality. These are, General, Latin American, far Eastern, South Asian, and Chilean (United Nations Department of International Economics, 1990). The General pattern was created as an average of all the observations (INDEPTH Network, 2004). These mortality patterns were determined by geographical setting and statistical analysis of estimated regression equations and adjusted model life tables for developing countries (Murray et al., 2000).

The Latin American model is characterised by high mortality during the infant and childhood years due mainly to excess diarrhoeal and parasitic diseases. There are also relatively low mortality levels in older ages, apparently because of comparatively low death rates due to cardiovascular disease and high mortality during the young adult ages (Department of International Economic and Social Affairs, 1983).

The Chilean pattern is characterised mainly by an extremely high infant mortality in relation to child mortality. The excess infant mortality appears to be due mainly to deaths from respiratory diseases and may also be related to early weaning (Department of International Economic and Social Affairs, 1983; Murray et al., 2000).

The South Asian pattern is typified by extremely high mortality under age 15 years. There is also comparatively high mortality at older ages (over age 55). The corresponding mortality of the South Asian pattern during the prime adult ages is relatively low (Department of International Economic and Social Affairs, 1983; Murray et al., 2000).

The Far Eastern pattern exhibits very high death rates at the older ages, compared with those at younger ages. This pattern is due to the history of tuberculosis in the population. The General pattern is considered as an average of the four regional patterns (Department of International Economic and Social Affairs, 1983; Murray et al., 2000).

INDEPTH Model Life Tables for sub-Saharan Africa

In the early 1960s, several file-based research centres were formed to collect longitudinal data on births, deaths, and migration in some areas in Asia and sub- Saharan Africa. These research sites teamed together to form an international network, INDEPTH, in the late 90s (INDEPTH Network, 2004).

The INDEPTH model of life was proposed to fill the gap in the data sources for generating the Coale and Demeny, United Nations and Lederman

Model Life tables, and others which were generally lacking in sub–Saharan Africa. The INDEPTH model life table system is based on data from 17 Demographic Surveillance Sites (DSS) in sub-Saharan Africa: thus, 8 DSS from West Africa (three in Ghana), 2 DSS from Southern Africa, and 7 DSS from East Africa. The INDEPTH model of life table draws its bases from the Brass rational model (INDEPTH Network, 2004).

The INDEPTH model of the life table identifies two patterns. Pattern 1 reflects the mortality pattern in areas that have a low prevalence of HIV and AIDS. This pattern consists of mainly DSS in West Africa. Pattern 2 displays mortality patterns in areas affected by HIV and AIDS. The DSS was from Eastern and Southern Africa (INDEPTH Network, 2004).

The INDEPTH model life table is estimated using

$$0.5\, In\left(\frac{1-1x}{1x}\right) = \alpha + 5\beta In\left(\frac{1-1sx}{1sx}\right)$$

Where

1_x and 1_{sx} are the survival functions of an empirical and a model pattern respectively.

Brass Indirect Estimation Method

Brass pioneered the use of indirect methods in mortality estimation in the 1950s. The Brass method is based on three fundamental requirements of information: information on children ever born, a number of children born alive who are dead (stillbirths and abortions are excluded), and the total number of the female population in their reproductive age (15 – 49) in the age group of five (United Nations Department of International Economics, 1990). This information may be acquired from censuses or surveys.

The Brass method permits making estimations from the proportions of children dead to the probability of dying (Department of International Economic and Social Affairs, 1983). There is numerous and various editions of the Brass method and the two widely use versions are the Trussell and the Palloni-Heligman versions.

Comparative Analysis of Direct and Indirect Methods

Adhikari (2015), using data from the 2011 Nepal Demographic and Health Survey, estimated childhood mortality from children surviving and children ever born in Nepal. The United Nations software for estimating mortality, known as, MortPak, was used for the estimations. The study used three indirect methods of estimations, namely, the Trussell method, the Feeney method, and the Palloni and Heligman method. The study applied the CEBCS application which is based on children ever born and children surviving by age of mother. The general mortality pattern of the UN model for developing countries and the Coale – Demeny West model life table was used for the study (Adhikari, 2015).

The study used the weighted average estimations of the 20 – 24 and 25 – 29 age group. The results from the study showed that infant mortality was 54.6 per 1000 live births using the Trussell method, 54.3 per 1000 live births using Palloni and Heligman method, and 52.7 per 1000 live births using Feeney. However, Adhikari (2015) realised that there were some differences between his estimations and published figures. The lesson we can learn is that where there are challenges with vital registration demographic indicators are based on indirect methods.

The study made use of data from the Nepal Demographic and Health Survey which gave the author the needed sample for the estimations. The study used the weighted average estimations of 20 – 24 and 25 – 29 age groups. Estimations from those aged 20 – 24 may be exaggerated because those in the age group would have been in the age group 15 – 19 years 0 – 4 years prior to the survey. The United Nations, in their document "Step-by-step Estimation of Childhood Mortality," proposed that the average estimates of those in the age group 25 – 29, 30 – 34, and 35 – 39 years should be used (United Nations Department of International Economics, 1990).

Similar results were seen by Susuman (2012) in his study on the child mortality rate in Ethiopia. His study used data from the 2000 and 2005 Ethiopian Demographic and Health Surveys. The study estimated child mortality using Brass and Trussell's indirect methods. The Trussell method was based on the North model and the Brass model was based on the South Asian model. The study applied the MortPak mortality package and used information on the duration of marriage, children ever born, children surviving, and the mean age of childbearing. Results showed that infant mortality has declined over the years, but infant mortality rates were still high. Results from the Trussell method were a bit higher than the Brass method. The possible explanation may be that the Coale-Demeny West model life tables relate better to Ethiopia than the South Asian pattern model life table.

In addition, a study by Quattrochi and colleagues that looked at calculating and correcting bias in indirect estimates of under-five mortality in

HIV/AIDS-affected populations found that under-five mortality in HIV prevalence populations of 0-41 percent can be underestimated. The study used a sample of 4480 (Quattrochi, Salomon, Hill, & Castro, 2019). The lessons learned from this research are that in HIV/AIDS-affected populations, mortality below 5 is skewed. HIV and AIDS in such populations should be accounted for when calculating mortality below 5.

In addition, a study in Bangladesh aimed at predicting childhood mortality found that mortality rates were higher for males than for females. It was also known that with the growing age of the mother, the risk of dying increases (Islam, Rahman, & Rahman, 2012). The research made use of data from the 2004 Demographic and Health Survey of Bangladesh. The research used three indirect approaches, namely the techniques of Brass, Sullivan, and Trussell. The study used a total of 8,721 women aged 10 to 49 years who had never been married and had at least one child. The study's calculations were based on the model life tables of Coale and Demeny West. Their results showed that the probability of dying rises with the rising age of the mother for the case of the Brass technique. Similar patterns were seen using the Sullivan technique except for the males and both sexes of the urban level in Bangladesh. In all the indirect techniques, the probability of dying was greater for males than for females.

Using the Trussell version of the Brass indirect form, a study by Lee and colleagues estimated child and under-five mortality. The findings showed that infant mortality was higher for males than for females under five. Their research analyzed infant and child mortality patterns and determinants in Vietnam using data from multiple indicator cluster surveys in Vietnam in 2011, 2006, and 2000

(Lee, Do, Choi, Trinh, & To, 2016). They also found that low-educated women were more likely to have witnessed infant mortality.

Using data from 13 demographic and health surveys in Africa.

Adetunji (1996) investigated whether the estimation method could affect the level of infant mortality in Africa. Indirect estimates were obtained in his estimation by applying the Trussell version of the Brass method using the computer-based program CMORT, and the results were crosschecked with the program MORTPAK. Results were presented for women between the ages of 20 – 25 years, 25 – 29 years, and 20 to 29 years. A total number of 13 surveys from 13 countries in Africa were used for the analysis. The results showed that, in countries like Botswana, Nigeria, and Ghana, the indirect estimates for infant mortality were higher with indirect methods, compared to direct methods, whereas in countries like Kenya, Zambia, Namibia, Senegal, and Burkina Faso, direct estimations were higher than indirect estimations.

Similar findings were shown by Adedini (2013) in his research that used the Nigeria Demographic and Health Surveys of 2003 and 2008 to determine the contextual determinants of infant and child mortality in Nigeria. By applying the Trussell and Palloni-Heligman versions of the Brass using the MORTPAK computer software, the infant and child mortality figures were obtained. The study findings showed that infant and child mortality rates for males were higher than for females. The findings also showed that estimates of the results of Palloni-Heligman were higher relative to those of the Brass system version of Trussell (Adedini, 2013).

Nevertheless, a study using complete birth histories and summary birth histories to look at infant mortality rates found that estimates obtained from indirect methods were higher than those obtained from direct methods (Silva, 2012). The research used data collected from South/Southeast Asia, Latin America, East Africa, and West Africa from demographic and health surveys. Chifundo (2009) saw similar findings when he contrasted direct and indirect trends in childhood mortality in high HIV settings. He used data from the Population and Health Survey of Malawi and Kenya. Compared to that of direct methods, he found findings from indirect methods were higher, and late begins to swing below the estimate from direct methods after 1990.

In addition, Ekisa's (2014) analysis of estimating infant and childhood mortality rates and patterns in Kenya found that infant and under-five figures were higher with direct methods compared to indirect methods. From 1982 to 2004, the study looked at patterns using demographic and health survey results.

Socio-Economic Dynamics of Infant and Under Five Mortality

In almost all its types, educational attainment has been recorded to be correlated with mortality. The association between maternal education and childhood mortality has been recorded by several studies. For example, in all four DHS reports from 1991 to 2011 in Nepal, Pathak (2017) recorded that the continuous trend in child mortality trends was high among uneducated and less educated mothers. In a cross-sectional baseline analysis that explored the socio-economic and demographic determinants of under-five mortality in rural northern Ghana, Kanmiki et al. (2014) reported similar findings. 3,975 women aged 15 to 49 years who had never given birth were sampled in the study. Their study found that in rural northern Ghana, women with no formal education had the highest share of under-five mortality.

In a similar study, parents' education was reported to be significant in child mortality. However, mothers' education was reported to have a stronger association with child mortality especially in rural areas (Hossain & Islam, 2008). This potential impact of mothers' education serving as a protective factor against childhood mortality could be because, in most developing countries, taking care of the child, usually at the household, is the responsibility of the mother and, therefore, an educated mother may be less likely to adopt poor childcare measures (see Islam, Rahman, & Hossain, 2013). Likewise, in a related study in Pakistan, mothers' education reduced child mortality as a result of higher household income, media exposure, literacy skills, access to health records, job status of the mother and mother's empowerment in the house of her husband (Aslam & Kingdon, 2012).

It has also been shown that wealth status is linked to child and under-five mortality. In their research examining the socio-economic determinants of infant mortality in Nepal, which used data from the 2011 Nepal Demographic and Health Survey, Khadka and colleagues found that births of women with the lowest wealth status had the highest rate of mortality in Nepal under the age of five (Khadka, Lieberman, Giedratis, Bhatta, & Pandey, 2015). In their research that used the 2013 Nigeria Demographic and Health Survey to analyze maternal education, household income, and infant mortality in rural Nigeria, Ashagidigbi and colleagues found the same findings (Ashagidigbi, Adewumi, Olagunju, & Ogunniyi, 2018).

Lartey, Khanam, and Takahashi (2016) have seen similar findings in their study that evaluated the effect of household wealth on child survival in Ghana. Their research used data from four Demographic and Health Survey rounds, including 1993, 1998, 2003, and 2008. To estimate the impact of wealth on child survival, they implemented the Weibull hazard model with gamma frailty. Their study found that there was a major association between the state of wealth and the survival of children. Women with the lowest income status had the highest proportion of childhood mortality, they realized.

This finding has also been confirmed by Collison, Dey, Hannah, and Stevenson (2007) when they reported a strong association between childhood mortality and income inequalities in wealthy nations. However, in wealthy nations, families, and households that depend on aid were reported to have higher under 5 mortality than families that do not depend on aid.

In a study by Ezeh et al., women from rural areas were shown to have the highest rates of child and under-five mortality (2015). Their research investigated the risk factors in Nigeria for post-neonatal, baby, boy, and under-five mortality. The research used data from the Nigeria Population and Health Survey from 2013, 2008, and 2003. Using the Cox regression model, information on 63,844 singleton live-born children of the most recent birth was analyzed. In their research in rural northern Ghana, Kanmiki and colleagues obtained similar results (Kanmiki, et al., 2014).

Moreover, a multi-country analysis that used demographic and health survey data from five countries in sub–Saharan African observed that women from rural residents have a greater likelihood of under-five mortality, as matched to those from the urban centre. The study used a total sample of 68,085 women aged 15 to 49 years. Multivariable Cox proportional hazard regression was used for the study (Yaya, Bishwajit, Okonofua, & Uthman, 2018).

Similar findings were seen in Ethiopia in their analysis by Gebretsadik and his colleague, who investigated under-five mortality in Ethiopia's high mortality regions. They established that the highest share of under-five mortality was among women from rural areas. Their research used data from the 2011 Ethiopia demographic and health survey and a sample of 16,515 women who gave birth to a live baby five years before the survey. (Gebretsadik & Gabreyohannes, 2016).

CHAPTER THREE

SOURCES OF DATA AND METHODS OF ANALYSIS

Introduction

This chapter discusses the study area, research philosophy, research design, sources of data (acquisition of data, sampling procedure, description, and definition of variables), management, processing, and analysis of data.

Study Area

The study area is the Republic of Ghana falls on the West African Coast and has a total land area of 238, 533 square kilometres (Ghana Statistical Service, 2013). It is bordered by three French-speaking countries: north by Burkina Faso, west by Cote d'Ivoire, and east by Togo. The country lies between 4 ° and 12 ° N latitudes and 4 ° W and 2 ° E longitudes, and the Greenwich Meridian line passes through the sea point of Tema, about 24 kilometres from the capital, Accra. Except for a series of hills on the eastern frontier, Ghana is a low-lying country and Mountain Afadjato is the highest point (883 metres) above sea level west of the Volta Region. It is possible to divide the Republic of Ghana into three ecological zones: The Northern Savannah; the Forest Region, comprising the Middle Belt and the western parts of the country; and the Sandy Coast, supported by a coastal plain.

According to the National Population Census conducted in 1960, 1970, 1984, 2000, and 2010, the population of Ghana was 6,726,815; 8,559,313; 12,296,081; 18,912,079; and 24658,823 respectively (Ghana Statistical Service, 2013). This then gives an average growth rate of 2.4 percent between 1960 and 1970, 2.6 percent between 1970 and 1984, 2.7 percent between 1984 and 2000, and 2.5 percent between 2000 and 2010. Based on the 2010 Population and

Housing Census, the population density was 103 people per square kilometre, with a sex ratio of 95 males per 100 females. Seventy-three out of every 1,000 women aged 45-49 years have never had a child and the proportion of females aged 45-49 years by birth order decreases from 0.93 for birth order one to 0.54 for 10 or more birth orders in the overall population (Ghana Statistical Service, 2013).

Research Philosophy

Philosophy is considered particularly important in social sciences research since it serves as the foundation on which the entire work is built – conceptualization, data gathering, analysis, interpretation, and presentation of the final research report. There are two dominant research philosophies in social sciences research: positivism and interpretivism. The positivist philosophy is associated with quantitative methods, while the interpretivism philosophy is associated with qualitative methods (Creswell, 2012). In recent times, mixed method research has been able to draw on the philosophical foundations of both positivism and interpretivism, to give rise to a new paradigm known as pragmatism. The study is situated in the positivist philosophy.

Positivist paradigm

The positivist paradigm is derived largely from the philosophical ideas of the great French philosopher known as August Comte (Kaboub, 2008). Those who hold this paradigm are of the view that reasoning and observation are the ultimate methods of comprehending human behaviour. Positivists hold the view that true knowledge comes from the experience of the senses and can only be obtained through scientific inquiry. Thus, the focus of the positivist paradigm is uncovering the truth and reporting it through empirical means by ensuring objectivity (Collins, 2011). Scholars and researchers who share positivist paradigm classify positivism into three viewpoints: epistemological (Popper, 2008), methodological (Weber, 2004), and idealistic or philosophical views that include principles, morals, and ethics (Putman, 2006).

Positivists are of the view that the universe is guided by permanent and universal laws of causation and occurrences. These occurrences are often complex but could be overcome by reductionism which emphasises accurate measurements that will result in objectivity and reproducibility (Aliyu, Bello, Kasim, & Martin, 2014). Positivist researchers often use quantitative analysis, observational, and laboratory experiments as their methods of inquiry (Weber, 2004).

Research Design

The Ghana Demographic and Health Survey adopts a repeated cross-sectional research design. A cross-sectional research design helps to study the current behaviour, beliefs, practices, and attitudes of a specific group of respondents at a given moment in time (Creswell, 2014). This approach has been used based on the following factors: it has not been possible to obtain maximum population coverage; it has offered a better alternative as it addresses the sample population in a short period of time and provides comparable and equivalent outcomes. Creswell (2014) believed that a respondent's belief and attitude would be a measure of his or her perception of the problem at hand while the respondents' practices would reflect their behaviour in response to the problem at hand.

Source of Data

The research used data from the Ghana Demographic and Health Survey 2014 (GDHS). Since 1988, GDHS, a nationally representative survey, has been planned and performed every five years. Ghana is one of the developing countries included in the program for the Demographic and Health Survey. The GDHS concentrates on children, women and men and is intended to provide sufficient data to track Ghana's population and health conditions.

During these rounds, the survey gathers information on infant and child mortality, fertility, contraceptive use, maternal health, child health, nutrition of children and adults, much more. Ghana Demographic and Health Survey was carried out by the Ghana Statistical Service with ICF Macro, an international company providing technical support for the survey through Measure DHS.

The Ghana Demographic and Health Survey uses sample weights to adjust for under-and oversampling from survey biases which have the possibility of affecting the generalisability of results. Sample weights are variables used to account for variations in the likelihood of selection and interview between cases due to the nature or opportunity of the survey. (Ghana Statistical Service [GSS], Ghana Health Service [GHS], and ICF International, 2015; Ghana Statistical Service [GSS], Ghana Health Service [GHS], and ICF Macro, 2009; Ghana Statistical Service [GSS], Noguchi Memorial Institute for Medical Research, and ORC Macro, 2004).

9,396 women aged 15-49 from 11,835 households covering 427 clusters in Ghana were interviewed by the 2014 GDHS. It had a 97 per cent response rate (Ghana Statistical Service, Ghana Health Service, & ICF Macro, 2015). GDHS is funded by the United States Agency for International Development

(USAID) and the Government of Ghana (GoG) with the support of other donor agencies, such as the United Nations Population Fund (UNFPA), the United Nations International Children's Emergency Fund (UNICEF), the United Nations Development Programme (UNDP), the Danish Development Agency (DANIDA), the Ghana AIDS Commission (GAC), the United Nations Development Programme (UNDP), the Ghana AIDS Commission (GAC), the United Nations Development Programme (UNDP), the Danish Development Agency (DANIDA) (ILO).

Reasons for the Demographic and Health Survey

GDHS is collects information on maternal (antenatal, delivery, postnatal) and child (infant, child, under five mortality, nutrition and feeding practices) health. GDHS encompasses all the then ten regions of Ghana. It uses a standardised sampling and questionnaire. The GDHS has larger sample sizes. For instance, the GDHS interviewed 4,488 women in 1988 and 4,562 women in 1993. Whereas in 1998, it interviewed 4,843 women, in 2003, it interviewed 5,691. Also, in 2008 and 2014, it interviewed 4,916 and 9,396 women respectively. These larger sample sizes allow for more robust analysis.

Target Population

The target population was births in the five years preceding the survey by females aged 15 to 49 years with birth history who were either usual residents of the selected households or visitors present in the selected households on the night before the survey. Multiple births such as twins were recorded as two children.

Sampling Procedure

A two-stage sample design was used by GDHS. The first stage involved the collection of points or clusters from an updated master sampling frame developed from the most recent Ghana Population and Housing Census (Census enumeration area). Thus, the 2010 Population and Housing Census was the sampling frame of the 2014 GDHS (see Table 1). Systematic sampling of the households identified in each cluster was involved in the second stage of selection. Weights were calculated considering the respective clusters, households, and individual no-responses so that there will be representativeness.

Table 1: Sampling Procedure

Round	Sample Frame	Cluster	Household	All women Interviewed
6 (2014)	2010 PHC	427	12831	9396
5 (2008)	2000 PHC	412	11778	4916
4 (2003)	2000 PHC	412	6251	5691
3 (1998)	1984 PHC	400	6375	4843
2 (1993)	1984 PHC	400	5822	4562
1 (1988)	1984 PHC	150	4406	4488

Source: (GSS, GHS and ICF International, 2015; GSS, GHS and ICF Macro, 2009; GSS, Noguchi Memorial Institute for Medical Research and ORC Macro, 2004; Ghana Statistical Service and Macro International, 1999; Ghana Statistical Service and Macro International, 1994; Ghana Statistical Service and Macro International, 1989).

Acquisition of Data

The data for the research was acquired from Measure DHS online. A completed registration form was submitted to Measure DHS, along with a brief proposal showing what the data set was going to be used for, after which permission was granted to download the data set. Data files available were in SAS, SPSS, STATA, and CIPRO formats, and all STATA data files were chosen and downloaded.

The 2014 Ghana Demographic and Health Survey (GDHS) used the standard DHS model questionnaire developed by the DHS Program Measurement (GSS, GHS, and ICF International, 2015). Three model questionnaires were used by GDHS, namely, the household questionnaire, the female questionnaire, and the male questionnaire. The household questionnaire contained information on household members, household characteristics, weight, height, haemoglobin and malaria measurement for children aged 0-5 years; weight, height, haemoglobin measurement, and HIV testing for women aged 15-49 and men aged 15-59 years.

The female questionnaire provided information on the history of the respondent, contraception, reproduction, pregnancy and postnatal treatment, child health, immunization, nutrition and mortality, marriage, sexual behaviour, preference for fertility, the background of the husband and women, HIV and AIDS, other health conditions, domestic violence, and measurements of blood pressure.

In addition, information on the respondent's history, reproduction, contraceptive usage, marriage, and sexual activity, fertility orientation, employment and gender roles, HIV and AIDS, other health conditions, and measurements of blood pressure were also included in the men's questionnaire.

Seven data sets were derived from the three model questionnaires: household file, women's file, men's file, couples' file, children (0–60 months), birth file, and household members' files. The birth recode file was used for this study. The birth recode file data set contains information on maternal health (background, nutrition, reproduction, contraception, fertility preferences, pregnancy, postnatal care, HIV and AIDS, and other health issues) child health (immunisation, nutrition, and mortality), and household characteristics (sanitation, source of drinking water, distance to health facilty, and type of toilet facilities).

Furthermore, of the 9,396 women interviewed in the study, a total of 23,118 births were ever born, of which 14,697 births were born in the last five years before the survey to 5,884 women (Ghana Statistical Service (GSS), Ghana Health Service (GHS) and ICF International, 2015). Recent births, that is, records of births in the five years prior to the survey, were used for the purpose of the study.

Estimator Variable of Interest Aggregate by a Set of Variables.

The Estimator variable for the study was under-five mortality. The under-five mortality variable was derived from the question "is child alive?" (0= no alive and 1= yes), date of birth, and the age at death in months if dead. This study focused on all deaths among children between the ages of 0 to 59 months experienced by women who had their last birth in the five-year periods preceding the survey.

The risk of dying between birth and the first birthday is infant mortality (1q0). The risk of dying between birth and the fifth birthday is under-five mortality. Infant and under-five mortality are measures that are most used because of their developmental sensitivity and can thus be focused on planning, recording, and assessment. (Siegel & Swanson, 2008). Under-five mortality is an indicator of the Sustainable Development Goal (SDG) 3, target 3.2 (Desa U. N, 2016).

The estimates were disaggregated by five variables: age, level of education, residence, wealth status, and region of residence. These variables were used because they are the main socioeconomic variables that are commonly used to explain the estimated variable. The age group was classified into 7 age groups: 15-19 = 1, 20-24 = 2, 25-29 = 3, 20-34 = 4, 35-39 = 5, 40-44 = 6, and 45-49 = 7. Education levels were divided into four categories: no education = 1, primary education = 2, secondary education, higher education = 3. The residence form has been coded as urban = 1 or rural = 2. The state of wealth was listed as poorest = 1, poorer = 2, middle = 3, richer = 4 and richest = 5. Western= 1, Central= 2, Greater Accra= 3, Volta= 4, Eastern= 5, Ashanti 6, Brong-Ahafo= 7, Northern= 8, Upper East= 9, and Upper West= 10 were coded as the area of residence.

Assessment of Data Quality

The precision of childhood mortality estimations is affected by sampling and non-sampling errors. Sampling errors are inherent in data collection, due to the two-stage sampling procedure adopted by the GDHS. Sampling error can be evaluated statistically using methods such as Taylor linearization, Jacknife repeated linearization, heuristic technique, and Taylor expansion method. For survey estimation, GDHS utilizes the Taylor linearization method of variance estimation and Jackknife repeated replication methods for variance estimation of more complex statistics such as fertility and mortality rates (GSS, GHS, & ICF International, 2015).

Errors made in its data collection and processing phases can result in a non-sampling error. Errors in reporting age at death, for example, may result in the shift of death from one age group to another. Failure to record births that have not survived will lead to mortality being underestimated. There is also the risk of misreporting birth dates, thus birth displacement can also affect the accuracy of trends in mortality. At the same time, recall errors can occur during the more distant retrospective period.

The reliability of estimates of mortality depends on the complete documentation of dying children. Estimates of systemic mortality are limited to recent times, ideally between 0-4, 5-9, and 10-14 years prior to the survey. The other periods have slightly skewed numbers, apart from the first period (0-4 years).

For this study, mortality estimation was restricted to the point of 0-4 years before the survey and the most recent birth during the period. This period is more preferred due to its reduced effects of biases in the estimations and fewer errors due to recall biases.

Data Analysis

The statistical software STATA version 14 and MORTPAK version 4.3 were used to process the data. The MORTPAK software was used for estimating under-five mortality. It produces under-five mortality estimates for the Palloni-Heligman and Trussell variants of the Brass indirect estimation technique. The

Trussell variant is founded on the Coale-Demeny model life tables, whereas the Palloni-Heligman uses the United Nations mortality model for developing countries. Stata software was used to analyse the factors that explain childhood mortality.

STATA version 14 was used to estimate the infant and under-five mortality rates using direct methods. The MORTPAK version 4.3 was used to estimate the under-five and infant mortality rate using the indirect estimation technique. The application QFIVE – estimation of child mortality was used for the analysis. The input data needed for the application is the title of analysis, the month of enumeration, year of enumeration, sex (indicate if the life tables are for female, male or both sexes), the sex ratio at birth, mean age of childbearing and the data definition. There are five data definitions which are:

1. Number of children surviving, number of children ever born, and the number of women by age
2. Number of women by age, the number of children dead and number of children ever born
3. The number of women by age, the number of children dead, and the number of children surviving
4. The median number of children ever born and the ratio of children dead
5. The average number of children surviving, and the average number of children ever born

The results were weighted using the GDHS data set's available sample weight factor (v005). Univariate analysis was done, and tables and bar graphs displayed the results. Estimates of infant and under-five mortality were estimated using births from 0 to 4 years prior to the survey, but estimates were calculated for a 10-year period about the study's socio-economic dynamics. This was done in order to ensure a satisfactory case for statistical reliability and comparability with the Ghana Demographic and Health Survey (GSS, GHS, & ICF International, 2015).

Stata version 14 was used to test the differences between estimates of the direct, Trussell and Palloni-Heligman methods. Using the 'syncrates' command, the confidence intervals were obtained with direct methods. For the lower and upper limits of the confidence intervals, the mean estimator was used to get the average children ever born and children surviving. These parameters were fed into Mortpak version 4.3 for infant windows and under five mortality estimates for the confidence interval lower and upper boundaries.

The next chapter focuses on using a direct technique to estimate infant and under-five mortality. It looks at estimations for both sexes (males and females) and the socio-economic dynamics in the infant and under-five estimations using the direct technique. The results are presented in charts and tables.

CHAPTER FOUR

ESTIMATING INFANT AND UNDER-FIVE MORTALITY USING DIRECT METHOD

Introduction

Direct technique of estimation, the most preferable approach for demographers, work with complete, accurate, and reliable data. Where demographic data is unreliable due to factors such as over-reporting and misreporting of events, then the indirect method of estimation is preferable. This chapter addresses direct estimation approaches and uses details from the 2014 Ghana Demographic and Health Survey to apply them to child and under-five mortality. STATA version 14 and Microsoft Excel were used to conduct all analyses and the results are presented using tables and charts. Socio-economic characteristics such as region of residence, level of education, type of residence, and wealth status were disaggregated in the estimates to show the differentials between infant and under-five mortality rates.

Data Requirements and Assumptions

The data required for direct estimation are the year and month in which each child was born, and sex of the child alive, the survival status of the child (whether the child is dead or still alive). When the child is dead, the age of death is required. Direct estimations assume that the date of birth and the date of death are recorded accurately. The status of the child, whether dead or alive, is stated with comparable accuracy (Hill, 2013).

Data sources for direct estimations are vital statistics or registration, surveys, and census. Vital statistics or registration for Ghana, like other developing countries, are not reliable and accurate (Births and Deaths Registry, 2014; Moultrie et at., 2013) hence the reliance on national representative surveys like the Ghana Demographic and Health Survey, the Ghana Maternal Health Survey, and census.

Variants of Direct Estimation

There are three variants of the direct estimate method for estimating childhood mortality rates, defined as the vital statistics approach, the true cohort life table approach, and the synthetic cohort life table approach in the DHS Guide to Statistics (Croft, Trevor, Aileen, Courtney, & al., 2018).

The vital statistics method is the variant in which the number of deaths in children under 1 year of age or 12 months of age over a given period is split up by the number of births over the same period. A mortality rate, but not a probability, is estimated; a change in the number of births over time will alter the rate without adjustments in the underlying probabilities (Croft et al., 2018; United Nations Department of Economic and Social Affairs, 2011).

The true cohort life table method is one in which the number of births in that cohort is divided by the number of deaths in children under 1 year or 12 months of a particular birth cohort. This method gives real death probabilities; however, it has a downside that all children in the cohort must have been born at least 1 year before the survey in order to be completely exposed to mortality, thus not taking into account the latest experience (Croft et al., 2018). Another downside is that true cohort rates are not unique to a specific death period, but instead refer to the cohort's date of birth (see Figure 1). The child mortality rate applies to new births in the year for babies in a specific year. Any of the child deaths in a year may belong to the birth cohort of the previous year.

The system in which mortality probabilities for small age segments are combined into standard age segments based on real cohort mortality experience is the synthetic cohort life table approach. This method allows the most recent data to be completely used and is therefore accurate for periods of time (Croft et at., 2018; Newell, 1990).

Most household surveys, such as the World Fertility Survey and Demographic and Health Survey, have adopted the synthetic cohort life table approach, although the approach specifics may vary from household survey programs (United Nations Department of Economic and Social Affairs, 2011). In this analysis, the synthetic cohort life table strategy was employed.

Considerations in Using the Synthetic Cohort Life Table Approach

Before using the synthetic cohort method, there are three main decisions to be considered: the length of the individual age segments, handling the age at death with inaccurate and incomplete details, and handling the heaping of deaths at 1 year or 12 months.

For the estimation of the probabilities of person dying, the following age segments were adopted by the DHS months: 0, 1-2, 3-5, 6-11, 12-23, 24-35, 36-47, 48-59. The questionnaire for DHS records the age of death. Data is reported in days of less than 0 to 30 days, in months of 1 to 23 months, and in years of 2 years or longer (Croft et al., 2018; United Nations Department of Economic and Social Affairs, 2011).

The DHS has assigned death ages to a 'hot deck' method in the handling of children with missing information, which imputes the death age based on the child's information of the same parity and mode of reporting (day, month, or year) found in the data file. If available, the data file that almost precedes the data file is allocated to the child for whom the age of death is missing. In the data collection, this quasi-random approach preserves the variance of responses (Croft et al., 2018; United Nations Department of Economic and Social Affairs, 2011).

The DHS does not change the age of death to 1 year or 12 months for heaping. The explanation is that heaping is likely to come inequitably from both sides of the 1-year cap and the correct number of deaths to adjust is unknown; the rates are calculated using the data as reported (Croft et al., 2018; United Nations Department of Economic and Social Affairs, 2011).

Application of the Direct Methods

Infant and under-five mortality were estimated using STATA. The syncmrates command was applied to v008, b3, b7, [iw=wt], and cluster (v021). Where v008 is the date of the interview; b3 is the date of birth; b7 is the age at death; [iw=wt] is the applied weighting, and v021 is the primary sampling unit. Syncmrates command calculates mortality rates applying the synthetic cohort probability approach employed in the DHS. This approach is based on the full birth history approach.

The information needed for the direct methods is the birth date of a child (b3), child survival status (1=alive, 0=dead) (b5), age at death in months (b7), data interview was conducted (v008), and individual sample weight (v005). Mortality rates are calculated by first tabulating the component death probabilities. A time period and age interval determine the component death risk. The age segments calculated are 0, 1 – 2, 3 – 5, 6 – 11, 12 – 23, 24 – 35, 36 – 47, and 48 – 59 months of complete age. There are three birth cohorts of children.

The cohort of children in cohort Y is fully included in the time period, while cohort X and cohort Z are partially included in the time period (see Figure 1). The lower limits of the age group are given by a_1 whereas the upper limits are represented by a_2. The lower time period and upper time periods are represented by t_1 and t_2 correspondingly. The three birth cohorts are defined as children born between the date:

i. $t_1 - a_2$ and $t_1 - a_1$ for cohort X
ii. $t_1 - a_1$ and $t_2 - a_2$ for cohort Y
iii. $t_2 - a_2$ and $t_2 - a_1$ for cohort Z

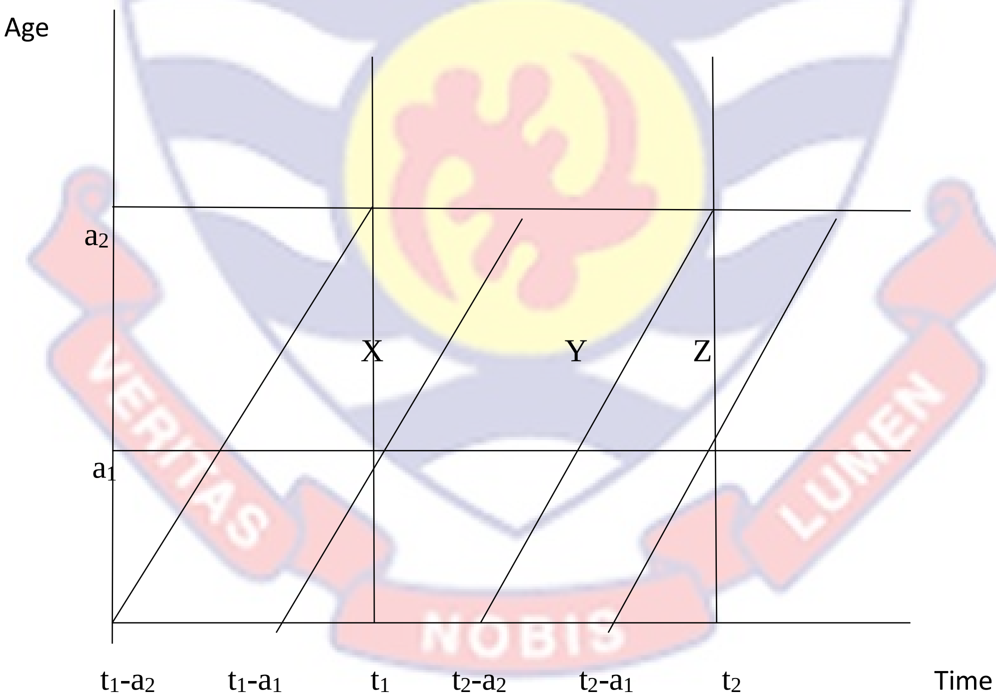

Figure 1: Births Cohorts
Source: Croft et al. (2018)

The time periods are expressed in the form of [t_1, t_2]. Thus, t_1 up to but not including t_2 ($t_1 > t_2$). The time periods used are normally five years or ten years preceding the month of the interview. Which is calculated $t_1 =$ v008 – 60

t_2 = v008 for five years preceding the survey and t_2 = v008 – 60 for ten years preceding the survey (Croft, Trevor, Aileen, Courtney, & al., 2018).

The age groups are stated in the form of [a_1, a_2]. Thus, from a_1 up to but not including a_2. For each age group, the time period, the numerators, and denominators are calculated. The component death probabilities are derived by dividing the numerator for each age group and time period by the denominator for the age group and period.

0	$a_1=0$	$a_2=1$
1 – 2	$a_1=1$	$a_2=3$
3 – 5	$a_1=3$	$a_2=6$
6 – 11	$a_1=6$	$a_2=12$
12 – 23	$a_1=12$	$a_2=24$
24 – 35	$a_1=24$	$a_2=36$
36 – 47	$a_1=36$	$a_2=48$
48 – 59	$a_1=48$	$a_2=60$

Numerators

i. One-half of the deaths between ages a_1 and a_2 to children of cohort X ($a_1 <= b7 < a_2$ & $t_1 - a_2 <= b3 < t_1 - a_1$), plus

ii. All of deaths between ages a_1 and a_2 to children of cohort Y ($a_1 <= b7 < a_2$ & $t_1 - a_1 <= b3 < t_2 - a_2$), plus

iii. One-half of the deaths between ages a_1 and a_2 to children of cohort Z ($a_1 <= b7 < a_2$ & $t_2 - a_2 <= b3 < t_2 - a_1$)

Denominators

i. One-half of the survivors at age a_1 of children of cohort X ((b5=1 or $a_1 < = b7$) & $t_1 - a_2 <= b3 < t_1 - a_1$), plus

ii. All the survivors at age a_1 of children of cohort Y

((b5=1 or $a_1 < = b7$) & $t_1 - a_1 <= b3 < t_2 - a_2$), plus

iii. One – half of the survivors at age a_1 of children of cohort Z

((b5=1 or $a_1 < = b7$) & $t_2 - a_2 <= b3 < t_2 - a_1$)

From a three-step estimation method, infant mortality rates are obtained. Second, you measure the probabilities of component survival by subtracting each likelihood of component death. Secondly, for 0, 1-2, 3-5 and 6-11 months of age, you measure the product of the variable survival probabilities. Third, to obtain the infant mortality rate, deduct the product from 1 and multiply it by 1000.

Under-five mortality rates are achieved through a three-step approach to calculation. Phase 1 - Measure the probabilities of component survival by subtracting each likelihood of component death. Phase 2 - For 0, 1-2, 3-5, 6-11, 12-23, 34-35, 36-47, and 48-59 months of age, measure the product of the variable survival probabilities. Phase 3 - To get the child mortality rate, deduct the product from 1 and multiply by 1000.

Estimation of Infant and Under Five Mortality using Direct Methods

Generally, the findings of the study showed that the infant mortality rate was 41 deaths per 1000 live births using the direct method of calculation (44 for males and 38 for females), while the under-five mortality rate was 60 deaths per 1000 live births (67 for males and 52 for females) (see Table 2).

Table 2:Estimation of Infant and Under Five Mortality using Direct Methods

Mortality Rate	Both Sexes	Male	Female
Infant mortality	41	44	38
Under-five mortality	60	67	52

Source: Computed from GDHS 2014 per 1000 live births

Socio-Economic Characteristics of Infant mortality Using the Direct Method

Table 3 shows the socio-economic characteristics of infant mortality using direct methods. Infant mortality was higher for those in the urban areas, thus, 49 deaths (53 for males and 45 for females) per 1000 live births, compared to those in the rural areas 46 deaths (50 for males and 42 for females) per 1000 live births (see Table 3).

Women with the poorest wealth quintile had the highest rate of infant mortality, that is, 55 deaths (57 for males and 53 for females) per 1000 live births (see Table 3). Concerning the region of residence, infant mortality ranged from 37 deaths (34 for males and 39 for females) per 1000 live births in the Greater Accra region to 64 deaths (79 for males and 48 for females) per 1000 live births in the Upper West region (see Table 3).

Table 3: Socio-Economic characteristics of Infant Mortality Using the Direct Method

Background characteristics	Both Sexes	Male	Female
Region			
Western	40	55	24
Central	48	55	41
Greater Accra	37	34	39
Volta	42	36	48
Eastern	43	38	49
Ashanti	63	74	54
Brong Ahafo	38	53	22
Northern	53	50	56
Upper East	46	50	43
Upper. West	64	79	48
Place of residence			
Urban	49	53	45
Rural	46	50	42
Wealth status			
Poorest	55	57	53
Poorer	44	49	39
Middle	39	44	35
Richer	47	55	40
Richest	51	53	49
Level of education			
No education	53	63	43
Primary	51	51	50
Secondary	42	44	40
Higher	45	52	38

Source: Computed from GDHS 2014 per 1000 live births

Women with no education had the highest rate of infant mortality, that is, 53 deaths (63 for males and 43 for females) per 1000 live births (see Table 3), whereas those with secondary education had the lowest rate of infant mortality (42 deaths [44 for males and 40 for females] per 1000 live births).

Socio-Economic Characteristics of Under-Five Mortality Using Direct Methods

The estimations of under-five mortality using direct methods are presented in Table 4. There were variations in under-five mortality with respect to the region of residence. The under-five mortality ranged from 47 deaths (50 for males and 43 for females) per 1000 live births in the Greater Accra Region to 112 deaths (117 for males and 104 for females) per 1000 live births in the Northern Region (see Table 4).

Under-five mortality was higher for those in the rural areas, 73 deaths (82 for males and 67 for females) per 1000live births, compared to those in the urban areas 64 deaths (72 for males and 56 for females) per 1000 live births (see Table 4). Women with the poorest wealth quintile had the highest rate of under-five mortality, that is, 92 deaths (101 for males and 81 for females) per 1000 live births (see Table 4).

Table 4: Socio-Economic dynamics of Under-Five Mortality Using Direct Methods

Background characteristics	Both Sexes	Male	Female
Region			
Western	56	71	40
Central	69	82	55
Greater Accra	47	50	43
Volta	61	48	77
Eastern	68	65	72
Ashanti	80	95	65
Brong Ahafo	57	76	37
Northern	111	117	104
Upper East	72	77	67
Upper West	92	107	75
Place of residence			
Urban	64	72	56
Rural	75	82	67
Wealth status			
Poorest	92	101	81
Poorer	73	82	63
Middle	61	64	57
Richer	55	62	48
Richest	64	71	56
Level of education			
No education	92	106	77
Primary	72	73	71
Secondary	55	60	49
Higher	48	59	38

Source: Computed from GDHS 2014 per 1000 live births

Also, women with no formal education had the highest rate of under-five mortality, thus, 92 deaths (106 for males and 77 for females) per 1000 live births (Table 4), whereas those with higher education had the lowest rate of under-five mortality (48 deaths [59 for males and 38 for females] per 1000 live births).

Discussion and Conclusion

This chapter estimated infant and under-five mortality using the direct estimation technique. The same method of analysing the 2014 GDHS report was followed. This study went further to include estimations of infant and under-five mortality for males and females, unlike the GDHS report which reported infant and under five mortality for only both sexes. In comparison with the GDHS report, findings from the study were equivalent to what was reported in the 2014 GDHS reports for both infant mortality and the under-five mortality (Ghana Statistical Service (GSS), Ghana Health Service (GHS) and ICF International, 2015).

Findings from the study show that the mortality rate of males was higher compared to that of females. This is consistent with the findings of Silva (2012), who looked at the estimations of child mortality using summary and full birth history. The male-female differential in mortality is universal where males are seen dying at a faster rate, as compared to females, even though the sex ratio at birth favours the males.

Furthermore, the results of the study showed that women from the urban centre had the highest share of infant mortality compared to those from rural areas. The possible explanation may be underreporting, or omission of death in the rural areas and the quality of data collected. This finding goes contrary to the pattern of infant mortality in Ghana, which is that rural areas having the larger share of infant mortality as seen in earlier studies and reports (GSS, GHS, and ICF Macro, 2009; GSS, Noguchi Memorial Institute for Medical Research and ORC Macro, 2004; Ghana Statistical Service and Macro International, 1999; Ghana Statistical Service and Macro International, 1994; Ghana

Statistical Service and Macro International, 1989). The Ghana Maternal Health Survey in 2017 also confirmed that women in the rural areas had the highest rate of infant mortalities compared with those from the urban areas (Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF, 2018)

Another possible explanation may be the use of caregivers in the urban centre. There is an increasing demand for a caregiver in the urban centre due to the workloads of mothers. Some of these caregivers may not have adequate training and this may explain the higher rate of infant mortality in the urban centre. Contrary to this finding, Ezeh et al. (2015) observed in their study that used data on 63,844 singletons, live-born infants, in Nigeria that women from rural areas had the highest share of infant mortality rates. My study also revealed that women from rural areas had a higher rate of under-five mortality. This is consistent with the findings of Kanmiki et al. (2014) and Ezeh et al (2015).

Findings suggest that women with no education had the highest rate of infant and under-five mortality rates using the direct method estimates, and this is similar to other studies (see Aslam & Kingon, 2012; Kanimiki et al., 2014; Pathak, 2017). For instance, Kanimiki et al. (2014), in their study in rural northern Ghana, observed that women with no formal education had the highest share of under-five mortality. The possible explanation may be that women without formal education may not have adequate knowledge of the danger signs of under-five mortality.

Also, results from the study showed that women with the poorest wealth quintile had the highest rate of both under-five and infant mortality rates using the direct method estimates. Studies have linked the poorest status to under-five and infant mortality (see Collison, Dey, Hannah, & Stevenson, 2007). The results of a study that assessed the impact of household wealth on child survival in Ghana show that there is a significant association between wealth status and child survival. It was observed that women with the poorest wealth status had the highest share of childhood mortality in Ghana (Lartey, Khanam, & Takahashi, 2016). The possible explanation would be women from the poorest households may not be able to afford good nutrition and the cost of seeking health care and these may affect the health of the child.

Nevertheless, it was observed from the study that women from Upper West had the highest share of infant mortality, while those from the Northern region had the highest rate of under-five mortality. Similar results were observed by Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International (2015). The possible explanation may be because the distribution of health care facilities and skilled providers is to the advantage of those in the coastal and forest zones, with only a handful in the northern and savannah zones (Ghana Health Service, 2010). The Kassina Nankan districts in the Upper East is an example of what good health facility can do. These districts have benefited immensely from the Navrongo Health Research Centre surveillance system, which periodically checks the health care of their residence. These has helped reduced the infant and under five mortality in the districts and Upper East Region at large.

The next chapter estimates infant mortality using indirect estimation techniques and compares the results with that from the direct estimation technique. Two indirect methods namely, Trussell and Palloni-Heligman variants of the Brass model were used. The Trussell variant is based on the

Coale and Demeny model life tables, whereas the Palloni-Heligman variant is based on the United Nations model life tables for developing countries.

CHAPTER FIVE

ESTIMATING INFANT MORTALITY RATE USING INDIRECT METHOD

Introduction

The indirect method technique is an approach of estimating demographic indicators where there are challenges with completeness and accuracy of data due to incomplete vital registration systems. As a result, indirect estimation techniques based on survey data have been used to estimate events such as childhood mortality. This chapter explores the Trussell and Palloni-Heligman indirect techniques to estimate infant mortality for Ghana and compares the results with that of direct estimation technique. Four social-economic characteristics (the region of residence, place of residence, wealth status, and level of education) are used for the comparison. The objective is to demonstrate how the results from the indirect methods compare with those using direct estimation techniques.

Data Requirements

The estimations use data on children ever born (CEB) and children surviving (CS) born to women aged 15 – 49 years, the month and year of enumeration, sex (the type of life table – male, female or both sexes), the sex ratio at birth and the mean age at childbearing. These variables are available in the Demographic and Health surveys and censuses undertaken in the country (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013).

Application of the Technique of the Indirect Method

Infant and under-five mortality estimations were carried out by using the QFIVE application based on MORTPAK software version 4.3 using on the Trussell and Palloni-Heligman variants of the Brass method. These estimations are done by calculating the average parity per woman, the proportions of children dead among those ever born, multipliers (for the Trussell variant) and mean age maternity (for Palloni-Heligman), the probability of dying at age x, and calculating for the reference date for each of the probabilities. Multipliers and the age of maternity are used to convert the proportions of the dead into probabilities of dying. The multipliers are based on the parity ratios which represent the fertility conditions of various ages. A full description of how these calculations are done is presented under that analytical method in Chapter Two.

Mortality indices based on reports have shown that reports from younger (15 – 19) and older (40 – 44 and older) women tend to be inaccurate due to overestimations or omissions (Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013). For instance, available evidence suggests that infant and under-five mortality reports from women age 20 – 24 years tend to be overestimated, while children born to women aged 15 – 19 years are more likely to overestimate infant and under-five mortality. However, infant and under-five mortality for women 40 – 44 and 45 – 49 years tend to be underestimated. This may be as a result of recall bias deaths (GSS, 2013; Moultrie, Dorrington, Hill, Timaeus, & Zaba, 2013).

A decrease in average parities by age is a sign of the omission of children, especially dead children (Macinko, de Souza, Guanisc, & de Silva Simoes, 2007). It is expected that average parity should increase with age.

Women who have reached the end of childbearing are expected to have more children ever born, compared to those who are just starting childbearing.

To compare the infant and under-five mortality values over the period to which they refer, they are transformed into one parameter estimate. The transformation is done by summing up the infant and under-five mortality rates of age group 25 – 29, 30 – 34, and 35 – 39, finding the average and then multiplying the results by 1000 (GSS, 2013; Mokhayeri, Riahi, Rafiei, & Asadgol, 2020; Moultrie, Dorrington, Hill, Timaeus , & Zaba, 2013). This is done to convert the probability of dying to one parameter infant and under-five mortality rates.

Description of the estimation of Indirect Method

Trussell Variant of the Brass Method

The Trussell version was developed by Trussell in the late 1970s (Trussell, 1975). The Trussell version of the Brass system model is dependent on the Coale -Demeny model life tables. Its advantage over the earlier versions of the Brass method is that it provides estimates for both the probability of dying from death to exact ages in childhood and the time points of each probability.

Computational procedure

Data required

a. Number of children ever born in each five-age group
b. Number of children born alive who are dead in each five-age group
c. Female population in their reproductive age group (15 – 45)

There are five steps in the computation procedure of the Trussell version of the Brass model. The first step is the calculation of the average parity per woman.

The average parity per woman is calculated using the average number of children ever born by a woman.

$$P(i) = \frac{CEB\ (i)}{FP(i)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..1$$

Where:

P (i) represents the average parity of women of age group

CEB (i) represents the total number of children ever born by these women

FP (i) represents the total number of women in the age group

The second step is the calculation of the proportions of dead among children ever born. This is calculated using the ratio of the total number of children dead to the total number of children ever born.

$$D(i) = \frac{CD(i)}{CEB(i)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 2$$

Where:

D(i) denotes the proportion of children dead for women in the age group

CD(i) denotes the number of children reported dead

CEB (i) denotes the total number of children ever born by these women

The calculation of the multipliers in the third step. The basic equation for the estimation for the Trussell method is

$$k(i) = a(i) + b(i)\frac{P(1)}{P(2)} + c(i)\frac{P(2)}{P(3)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..3$$

Where:

k(i) signifies multipliers.

P (1)/P (2) and P (2)/P (3) indicates parity ratios

a(i), b(i) and c(i) signify coefficients.

The fourth step is calculating for the probabilities of dying by age x

$$q(x) = k(i)\, D(i) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . 4$$

Where:

q(x) represents the probability of dying by age x.

k(i) represents multipliers.

D(i) denotes the proportion of children dead for women in the age group.

The fifth step is calculating the reference date for each of the probabilities of dying. The reference date assumes that mortality has been steady over time. The reference time is calculated by:

$$t(i) = e(i) + f(i)\frac{P(1)}{P(2)} + g(i)\frac{P(2)}{P(3)} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 5$$

Where:

t(i) denotes the reference date.

P (1)/P (2) and P(2)/P(3) signifies parity ratios.

e(i), f(i) and g(i) are coefficients.

Palloni-Heligman Variant of the Brass method Computation

The Palloni-Heligman version of the Brass method was developed in the 1980s (Palloni & Heligman, 1985). This version is grounded in the United Nations model life tables for developing countries. Similar to the Trussell version, the Palloni-Heligman version also estimates the probability of dying but differs by adding information on births occurring in a given year. This additional information is used to determine the mean age at childbearing (United Nations Department of International Economics, 1990).

Computational procedure

Data required:

a. Number of children ever born in each five-age group.

b. Number of children born alive who are dead in each five-age group.

c. Female population in their reproductive age group (15 – 45).

d. Number of births occurring each year classified by age group of mothers.

There are five steps in the computation procedure of the Palloni-Heligman version of the Brass model. All the steps in the Palloni-Heligman version are the same as the steps in the Trussell version of the Brass method, except for the third step, where the calculation of the multipliers in the Trussell version is replaced by the calculation of the mean age of maternity.

The first step is the calculation of the average parity per woman. The average parity per woman is calculated using the average number of children ever born by a woman.

$$P(i) = \frac{CEB\ (i)}{FP(i)} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots ..1$$

Where:

P (i) represents the average parity of women of age group.

CEB (i) represents the total number of children ever born by these women.

FP (i) represents the total number of women in the age group.

The second step is the calculation of the proportions of dead among children ever born. This is calculated using the ratio of the total number of children dead to the total number of children ever born.

$$D(i) = \frac{CD(i)}{CEB(i)} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 2$$

Where:

D(i) denotes the proportion of children dead for women in the age group.

CD(i) denotes the number of children reported dead.

CEB (i) denotes the total number of children ever born by these women.

The mean age of maternity is the number of births occurring in a given year. The is calculated as:

$$M = \frac{\sum_{i=1}^{7}(B(i)mo\ (i))}{\sum_{i=1}^{7} B(i)} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3$$

Where:

$\sum$ signifies sum.

B(i) signifies the number of births to women in age group i

mp denotes midpoint in the year of age group i

The fourth step is calculating for the probabilities of dying by age x.

$$q(x) = k(i)\ D(i) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .4$$

Where:

q(x) represents the probability of dying by age x.

k(i) represents multipliers.

D(i) denotes the proportion of children dead for women in the age group.

The fifth step is calculating the reference date for each of the probabilities of dying. The reference date is based on the assumption that mortality has been steady over time. The reference time is calculated by:

$$t(i) = e(i) + f(i)\frac{P(1)}{P(2)} + g(i)\frac{P(2)}{P(3)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where:

t(i) denotes the reference date.

P(1)/P (2) and P(2)/P(3) signifies parity ratios.

e(i), f(i) and g(i) are coefficients.

Estimation of Infant mortality using Trussell Variant of the Brass Method

Infant mortality rates using the Trussell variant of the Brass Method are presented in Figure 2 and Table 5. Further details of the results are seen in Appendix A. For example, the probability of dying increases with the increasing age of mothers. The probability of dying by age increase from 0.027 for mothers age 20 – 24 years to 0.167 for mothers age 45 – 49 years old (see Appendix A). Generally, results from the study using the Trussell variant of the Brass method show that the infant mortality rate was 50 deaths (53 for males and 45 for females) per 1000 live births (see Figure 2).

Infant mortality rate ranged from 34 deaths (27 for males and 36 for females) per 1000 live births among women from Greater Accra region (see Table 5) to 75 deaths (85 for males and 64 for females) per 1000 live births among women from the Northern Region (see Table 5).

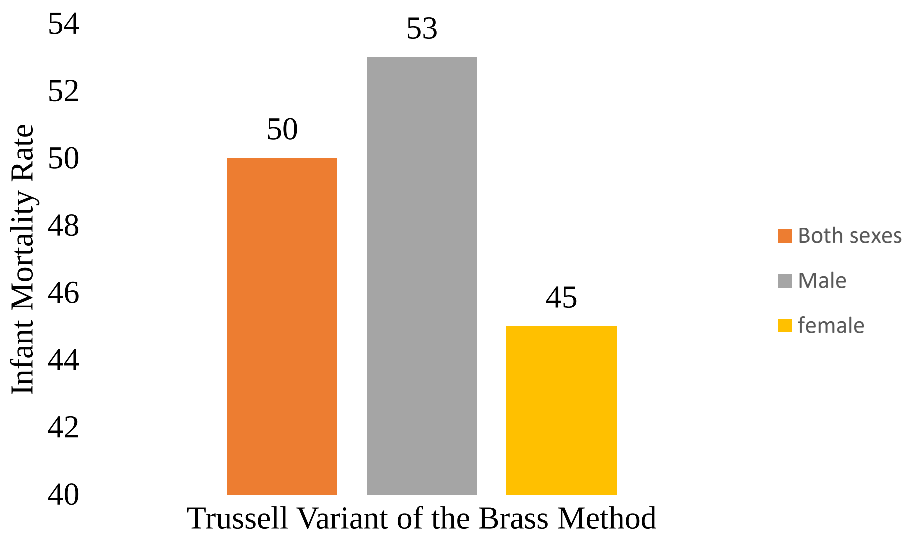

Figure 2: Infant mortality estimates using Trussell Variant of the Brass Method

Source: Computed from GDHS 2014

Findings from the study showed that the infant mortality rate for women in urban areas was 42 deaths (45 for males and 40 females) per 1000 live births, whereas the infant mortality rate for women in rural areas was 55 deaths (60 for males and 50 females) per 1000 live births (see Table 5).

Furthermore, infant mortality rate ranged from 41 deaths (46 for males and 34 for females) per 1000 live births among women with richest wealth quintile (see Table 5) and richer wealth status (42 deaths [46 for males and 34 for females]) to 65 deaths (71 for males and 58 for females) per 1000 live births among women with poorest wealth status (see Table 5).

Also, results from the study showed, infant mortality rate ranged from 34 deaths (38 for males and 31 for females) per 1000 live births among women with higher education to 63 deaths (72 for males and 54 for females) per 1000 live births among women with no formal education (see Table 5).

Table 5:Estimation of Infant mortality using Trussell Variant of the Brass Method

Background characteristics	Both Sexes	Male	Female	Reference Date
Region				
Western	35	42	30	2001.5 – 2011.3
Central	52	52	54	2008.3 – 2010.1
Greater Accra	34	27	36	2003.1 – 2010.9
Volta	43	45	40	2006.2 – 2010.2
Eastern	45	42	47	2004.3 – 2010.9
Ashanti	65	77	50	2005.9 – 2010.3
Brong Ahafo	46	49	37	2005.0 – 2010.6
Northern	75	85	64	2004.5 – 2010.7
Upper East	55	62	51	2004.9 – 2010.4
Upper West	69	79	62	2005.7 – 2010.8

Table 5 Continued

Place of residence				
Urban	42	45	40	2002.8 – 2011.0
Rural	55	60	50	2006.1 – 2010.6
Wealth status				
Poorest	65	71	58	2005.7 – 2010.5
Poorer	48	53	43	2005.5 – 2101.7
Middle	48	50	47	2005.4 – 2010.6
Richer	42	46	34	2002.6 – 2010.9
Richest	41	42	40	2001.2 – 2011.4
Level of education				
No education	63	72	54	2004.2 – 2010.8
Primary	52	45	60	2005.3 – 2010.8
Secondary	42	48	35	2004.8 – 2010.6
Higher	34	38	31	2006.7 – 2009.8

Source: Computed from GDHS 2014 per 1000 live births

Palloni-Heligman Variant of the Brass method

The Palloni-Heligman variant of the Brass method is based on the United Nations life table for developing countries. Results from the application of the Palloni-Heligman variant of the Brass method were obtained using version 4.3 of the MORTPAK (see Tables 6). Further details of the method of calculation of results can be seen in Appendix B. Generally, infant mortality rates are presented in Table 6. Findings from the study showed that the infant mortality rate was 57 deaths (63 for males and 52 for females) per 1000 live births (see Figure 3).

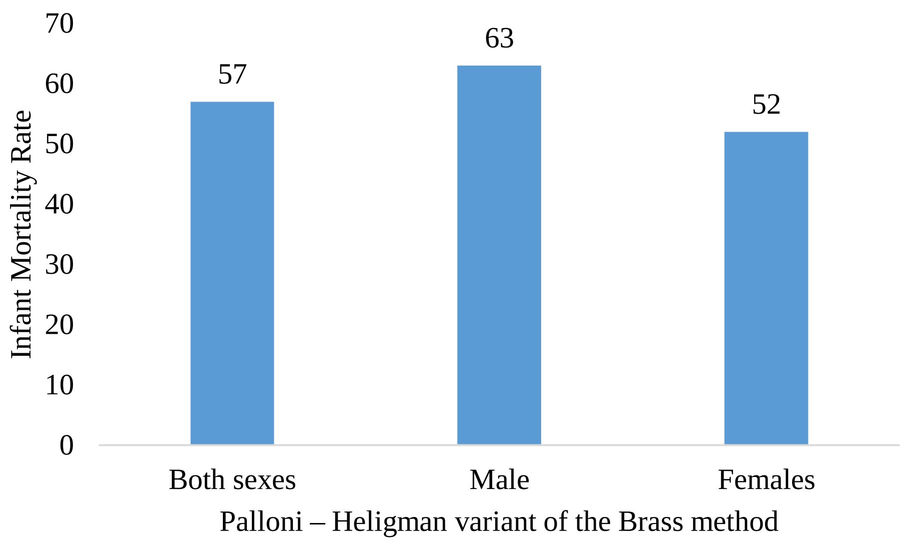

Figure 3: Infant mortality estimates using Palloni-Heligman variant of the Brass method

Source: Computed from GDHS 2014

Estimation of Infant mortality using Palloni-Heligman Variant of the Brass Method

Findings from the study showed that concerning the region of residence, infant mortality rate ranged from 32 deaths (30 for males and 35 for females) per 1000 live births among women from Greater Accra region (see Table 6) to 89 deaths (98 for males and 77 for females) per 1000 live births among women from Northern region (see Table 6).

Also, results from the study showed that the infant mortality rate for women in urban areas was 50 deaths (53 for males and 46 females) per 1000 live births (see Table 6) whereas the infant mortality rate for women in rural areas was 61 deaths (70 for males and 56 females) per 1000 live births (see Table 6).

Infant mortality rate ranged from 35 deaths (37 for males and 34 for females) per 1000 live births among women with higher education to 73 deaths (84 for males and 63 for females) per 1000 live births among women with no formal education (see Table 6).

Furthermore, for wealth status, infant mortality rate ranged from 48 deaths (56 for males and 38 for females) per 1000 live births among women with richest wealth quintile (see Table 6) and richer wealth status (49 deaths [50 for males and 47 for females]) to 73 deaths (79 for males and 67 for females) per 1000 live births among women with poorest wealth quintile (see Table 6).

Table 6: Estimation of Infant Mortality Using Palloni-Heligman Variant of the Brass Method

Background characteristics	Both Sexes	Male	Female	Reference Date
Region				
Western	43	51	34	2002.4 – 2013.3
Central	59	58	59	2008.1 – 2012.0
Greater Accra	32	30	35	2004.6 – 2013.1
Volta	47	49	44	2008.4 – 2013.0
Eastern	51	48	57	2006.4 – 2013.1
Ashanti	65	83	51	2007.8 – 2013.0
Brong Ahafo	49	57	42	2006.6 – 2013.1
Northern	87	98	77	2006.1 – 2013.1
Upper East	64	71	57	2006.7 – 2013.0
Upper West	79	92	69	2006.6 – 2013.1

Table 6 Continued

Place of residence				
Urban	50	53	46	2004.0 – 2013.2
Rural	61	70	56	2007.4 – 2013.0
Wealth status				
Poorest	73	79	67	2007.4 – 2013.1
Poorer	55	62	49	2007.1 – 2013.1
Middle	54	55	50	2008.1 – 2013.1
Richer	48	56	38	2004.2 – 2013.2
Richest	49	50	47	2002.3 – 2013.2
Level of education				
No education	73	84	63	2005.6 – 2013.1
Primary	59	52	65	2006.8 – 2013.1
Secondary	45	54	40	2006.4 – 2013.1
Higher	35	37	34	2006.7 – 2013.2

Source: Computed from GDHS 2014 per 1000 live births

Comparing Estimated Infant Mortality (Both Sexes) Using Direct and Indirect Methods

Results from the study reveal that infant mortality was higher using indirect methods of estimation, compared to direct estimation. For instance, infant mortality for both sexes was 41/1000 live births for the direct estimation and 50/1000 and 57/1000 live births for Trussell and Palloni-Heligman methods respectively (see Table 7).

With respect to the region of residence, it was seen that women from Upper West region had the highest rate (64/1000 live birth) of infant mortality, using the direct methods of estimation, but women from the Northern region were seen to have the highest rate of infant mortality (75/1000 and 87/1000 live births for Trussell and Palloni-Heligman methods respectively), using indirect methods of estimation (see Table 7). Women from the Greater Accra region had the lowest rate of infant mortality. For instance, the infant mortality was 37/1000 live births for the direct method of estimation, and the indirect methods of estimation recorded 34/1000 live births for the Trussell method and 35/1000 live births for the Palloni-Heligman method.

About the place of residence, the study revealed that there exist some differences in the estimations between the direct and indirect methods of estimations. Findings showed that the highest proportion of infant mortality was from women from the urban centre (49/1000 live births) using direct methods. However, the indirect method of estimation showed that rural women (55/1000 and 61/1000 live births using Trussell and Palloni-Heligman methods respectively) had the highest proportion of infant mortality (see Table 7).

Table 7: Differentials in estimating Infant mortality (Both sexes) using direct and indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	40	36	43
Central	48	53	58
Greater Accra	37	34	35
Volta	42	43	47
Eastern	43	45	51
Ashanti	63	65	67
Brong Ahafo	38	46	49
Northern	53	75	87
Upper East	46	55	64
Upper West	64	69	79

Table 7 continued

Place of residence			
Urban	49	42	50
Rural	46	55	61
Wealth status			
Poorest	55	65	73
Poorer	44	48	55
Middle	39	48	54
Richer	47	46	48
Richest	51	41	49
Level of education			
No education	53	63	73
Primary	51	52	59
Secondary	42	42	45
Higher	45	34	35
Total	41	50	57

Source: Computed from GDHS 2014 per 1000 live births

Results from the study showed that women with the poorest wealth quintile had the highest rate of infant mortality for both direct and indirect methods of estimations. They recorded 55/1000 live births for the direct method of estimation and 65/1000 live births and 73/1000 live births for Trussell and Palloni-Heligman methods respectively (see Table 7).

Furthermore, for the level of education, the findings from the study revealed variations in the direct and indirect methods of estimation for infant mortality. The highest proportion of infant mortality was among women with no formal education, using the indirect methods of estimation (63/1000 for Trussell and 73/1000 for Palloni-Heligman) (see Table 7). Estimations with the direct method also showed that women without no formal education (53/1000 live birth) had the highest rate of infant mortality (see Table 7).

Differences in Estimating Infant Mortality (Males) Using Direct and Indirect Methods

Table 8 reports the differences in estimating males' infant mortality using direct and indirect estimation methods. Generally, infant mortality for males was 44/1000 live births using direct methods, compared to indirect methods of 53/1000 live births and 63/1000 live births for Trussell and Palloni-Heligman methods respectively (See Table 8).

Concerning the region of residence, the estimations were higher for the indirect methods, compared to the direct methods. For instance, women from the Upper West Region had the highest rate of infant mortality for males (79/1000 live births), using direct methods, whereas women from the Northern Region were seen to have the highest rate of infant death (85/1000 live births) using the Trussell method and 98/1000 live births using Palloni-Heligman (see Table 8). Women from the Greater Accra Region had the lowest rate (Direct – 34/1000 live births, Indirect – 27/1000 live births using the Trussell method and

30/1000 live births using the Palloni-Heligman method) of infant mortality for males.

Table 8: Differences in estimating Infant mortality (Males) using direct and indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	55	30	51
Central	55	52	59
Greater Accra	34	27	30
Volta	36	45	49
Eastern	38	42	48
Ashanti	74	77	84
Brong Ahafo	53	49	57
Northern	50	85	98
Upper East	50	62	71
Upper West	79	79	92

Table 8 continued

Place of residence			
Urban	53	45	53
Rural	50	60	70
Wealth status			
Poorest	57	71	79
Poorer	49	53	62
Middle	44	50	55
Richer	55	46	56
Richest	53	42	50
Level of education			
No education	63	72	84
Primary	51	45	50
Secondary	44	38	54
Higher	52	38	37
Total	44	53	63

Source: Computed from GDHS 2014 per 1000 live births

Results also revealed that there were differences between the direct and indirect methods of estimating infant mortality for males, regarding the place of residence. The highest rate of infant mortality for males was women from urban areas (53/1000 live births), using direct methods, but women from rural areas were seen to have the highest rate of infant mortality for males, using indirect methods (60/1000 live births using Trussell methods and 70/1000 live birth using Palloni-Heligman) (see Table 8).

Similar differences were observed with wealth status and level of education. Regarding wealth status, the lowest rate of infant mortality for males was from women with middle wealth status (44/1000 live births), using direct methods, whereas women from richest wealth quintile were seen to have the lowest rate of infant mortality for males, using indirect methods (42/1000 live births and 50/1000 live births for Trussell and Palloni-Heligman methods respectively) (see Table 8).

Furthermore, women with a higher level of education had the lowest share of infant mortality for males, using the indirect method of estimation (38/1000 live births for Trussell method and 37/1000 live births for Palloni-Heligman method) while women with a secondary level of education (44/1000 live births) had the lowest share of infant mortality for males, using the direct method of estimation (see Table 8).

Differences in Estimating Infant Mortality (Females) Using Direct and Indirect Methods

Table 9 reports the differences in estimating females' infant mortality using direct and indirect estimation methods. Generally, infant mortality for females was 38/1000 live births using direct methods, compared to 45/1000 live births and 52/1000 live births for indirect methods of Trussell and Palloni-Heligman respectively (See Table 9).

Children of women from rural areas had the highest rate of infant mortality among females, using indirect (57/1000 live births for Palloni-Heligman and 50/1000 live births for Trussell) methods of estimation. However, children of women from urban centres had the highest rate of infant mortality, using direct methods (45/1000 live births) compared to those from the rural areas.

Results from the study also revealed differences between the direct and indirect methods of estimating infant mortality for females with respect to the region of residence. The highest rate of infant mortality for females came from women from the Northern Region (56/1000 live births), using direct methods. However, women from the Northern region (64/1000 live births using Trussell methods) and Upper West (79/1000 live birth using Palloni-Heligman) were seen to have the highest rate of infant mortality for females, using indirect methods (see Table 9).

Table 9: Differences in estimating Infant mortality (Females) using direct and indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	24	42	34
Central	41	54	59
Greater Accra	39	36	41
Volta	48	40	44
Eastern	49	47	57
Ashanti	54	50	50
Brong Ahafo	22	37	42
Northern	56	64	77
Upper East	43	51	57
Upper West	48	62	79

Table 9 continued

Place of residence			
Urban	45	40	46
Rural	42	50	56
Wealth status			
Poorest	53	58	67
Poorer	39	43	49
Middle	35	47	50
Richer	40	34	38
Richest	49	40	47
Level of education			
No education	43	54	63
Primary	50	60	65
Secondary	40	35	40
Higher	38	31	34
Total	38	45	52

Source: Computed from GDHS 2014 per 1000 live births

Similar variations were found about wealth status. Women with richer wealth status (34/1000 and 38/1000 live births for Palloni-Heligman and Trussell methods respectively) were seen to have the lowest share of infant mortality among females, using the indirect method of estimation (see Table 9) whereas the direct method of estimation showed that women with middle wealth status (35/1000 live births) had the lowest share of infant mortality among females.

Furthermore, the case was not different with the level of education. There were differences between direct and indirect estimations. Women with primary (50/1000 live births) education had the highest rate of infant mortality among females using direct methods (see Table 9). However, women with primary education (60/1000 live births) had the highest share of infant mortality among females using the Trussell method of estimation. Likewise, women with primary education (65/1000 live births) had the highest rate of infant mortality among females using the Palloni – Heligman method of estimation (see Table 9).

Test of Difference for Infant Mortality

This section examines whether there is a significant association between the difference in infant mortality estimates, using direct and indirect techniques. A test of difference was conducted to compare the infant mortality estimations using direct and indirect techniques.

There was no significant difference in the infant mortality estimates for region of residence for both sexes, using direct techniques and indirect techniques. For instance, the estimates using direct techniques, the infant mortality for western region was [40/1000 live birth, 95% Confidence interval of (28/1000, 51/1000)]. Whereas using indirect method the infant mortality for western region was [36/1000 live birth, 95% confidence interval of 29/1000, 43/1000)] using the Trussell technique and [43/1000 live birth, 95% confidence interval lower bound of 41/1000 and upper bound of 45/1000)] using Palloni-Heligman technique (see Appendix C).

Also, with respect to place of residence there a significant difference in the infant mortality estimates for using direct techniques (46/1000 live births, 95% Confidence interval= 40/1000 live births, 52/1000 live births) and indirect technique [Trussell (55/1000 live births, 95% confidence interval 54/1000 live births, 56/1000 live births) and Palloni – Heligman (61/1000 live birth, confidence interval 57/1000, 65/1000 live births)] (see Appendix C).

Furthermore, it was observed that there was no significant difference in the infant mortality estimates with respect wealth status, using direct techniques and Trussell technique. For instance, the infant mortality estimates for poorest wealth status using direct techniques (55/1000 live births, 95% Confidence interval lower bound of 46/1000 live births and upper bound of 65/1000 live births) and using Trussell technique (65/1000 live births, 95% confidence interval lower bound of 60/1000 live births and upper bound of 70/1000 live births) (see Appendix C).

Whereas there is a significant difference in the infant mortality estimate for poorest wealth status using direct technique (55/1000 live births, 95% confidence interval lower bound 44/1000 live births and upper bound 65/1000 live births) and Palloni-Heligman technique (73/1000 live births, 95%

confidence interval lower bound 67/1000 lives births and 79/1000 lives births) (see Appendix C).

A statistically significant association was expected, and this assumption was confirmed by the study. On this premise, we fail to accept the null hypothesis that there is no significant association between results from Direct and Trussell techniques for infant mortality. We also fail to accept the null hypothesis that there is no significant association between the results of Direct and Palloni-Heligman techniques for infant mortality.

Discussion and Conclusion

Generally, the study showed that results from the indirect techniques were higher than those from the direct technique. It was also observed that the results from the Palloni-Heligman variant were higher for infant mortality than that of the Trussell variant of the Brass model and the direct methods in all the socio-economic variables used.

The Palloni-Heligman variant seems to give a better estimation than the Trussell's and the direct methods (Adedini, 2013; Adetunji, 1996). Palloni-Heligman model is based on the United Nations model life table for developing countries whereas that of Trussell is based on Coale and Demeny life tables. The United Nations model life table was developed to address the needs of developing countries that were not captured in the earlier model life tables like the Coale and Demeny life tables (INDEPTH Network, 2004). Although both Palloni-Heligman and Trussell follow the same estimation procedures, the Palloni-Heligman technique adds the mean age of childbearing to its calculation, thus improving the robustness of the estimates (United Nations Population Division, 2003).

The Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International (2015) have reported that the Ghana 2014 Demographic and Health data on infant mortality were underreported. The finding that the Palloni-Heligman technique gives higher figures than both the Trussell and the direct methods could be due to its ability to make up for underreporting. Since the indirect technique uses summary birth histories and applies it to model life tables based on mathematically robust associations between demographic data and pattern of mortality (Moultire, 2015), it can make up for underreporting and omissions. However, the direct technique is dependent on the correct reporting of age at death (Croft, Trevor, Aileen, Courtney, & al., 2018).

It was observed that males had a higher rate of infant mortality than females. Studies conducted in developing countries have had similar results that mortality estimations are higher for males than for females (see Islam, Rahman & Rahman, 2012; Lee, Do, Choi, Trinh, & To, 2016). This is demographically expected to happen in developing countries.

Furthermore, the findings of the study showed that women from rural areas had the highest rate of infant mortality, using both the Trussell and the Palloni-Heligman techniques, whereas, in the case of the direct technique, it was women from urban areas who had the highest rate of infant mortality. The possible explanation may be because of the quality of reporting in the rural areas. The difference between the techniques was wide for results from rural areas, compared to that of the urban areas.

Also, the difference in infant mortality varied concerning the region of residence. For instance, the difference with infant mortality for the direct and indirect techniques was smaller for women in the Ashanti Region (Direct –

63/1000 live births; Trussell – 65/1000 live births; Palloni-Heligman – 67/1000 live births) whereas a wider difference was observed between direct and indirect techniques for women from the Northern Region (Direct – 53/1000 live births; Trussell – 75/1000 live births; Palloni- Heligman – 87/1000 live births). The possible explanation may be because of the quality of data from these regions. Infant mortality from the Ashanti Region may be reported better than that from the Northern Region.

It was also observed from the findings that the differences in infant mortalities between direct and indirect techniques were bigger for women with the poorest wealth status for both sexes. This gap closes with women who had improved wealth status. For instance, the infant mortality from women with the poorest wealth status was 57/1000 live births, using the direct technique and 71/1000 and 79/1000 live births, using Trussell and Palloni-Heligman respectively. The difference between the direct and indirect techniques was 14/1000 live births for Trussell and 22/1000 live births for Palloni-Heligman.

Whereas the gap was closer between direct and indirect techniques for women with middle wealth status for both sexes, the difference between the direct and indirect techniques was 6/1000 live births for Trussell and 11/1000 live births for Palloni-Heligman. This may be attributed to the quality of reporting of infant mortality among women with different wealth status.

The next chapter deals with using indirect techniques to estimate under-five mortality. It also discusses the results from the estimation of under-five mortality for both sexes, using indirect techniques, specifically Trussell and Palloni-Heligman variants of the Brass method, and comparing the results with estimates from the direct technique.

CHAPTER SIX

ESTIMATING UNDER FIVE MORTALITY USING INDIRECT METHODS

Introduction

This section uses indirect methods to estimate under-five mortality. It further compares the differences in estimations between the direct and indirect techniques of estimation. It compares under-five mortality for both sexes, males, and females, using the direct techniques and the indirect technique (the Trussell and Palloni-Heligman techniques). The results are presented in tables. Socio-economic characteristics such as place of residence, region of residence, level of education, and wealth status are used to show the differentials in under-five mortality rates.

Estimation of Under Five mortality using Trussell Variant of the Brass Method

The findings of the estimations of under-five mortality using the Trussell variant of the Brass method are presented in Table 10. Further details of the result can be seen in Appendix A. The under-five mortality rate was 74 deaths (78 for males and 68 for females) per 1000 live births (see Table 10).

Also, concerning the region of residence, results from the study showed that under-five mortality rate ranged from 43 deaths (35 for males and 52 for females) per 1000 live births among women from the Greater Accra region to 118 deaths (133 for males and 103 for females) per 1000 live births among women from the Northern Region (see Table 10).

Table 10:Estimation of Under-five mortality using Trussell Variant of the Brass Method

Background characteristics	Both Sexes	Male	Female	Reference date
Region				
Western	50	58	40	2001.5 – 2011.3
Central	79	75	85	2006.5 – 2010.4
Greater Accra	43	35	52	2003.1 – 2010.6
Volta	62	63	59	2006.2 – 2010.2
Eastern	65	60	72	2004.3 – 2010.9
Ashanti	88	117	68	2006.2 – 2010.4
Brong Ahafo	62	71	53	2005.0 – 2010.6
Northern	118	133	103	2004.3 – 2010.8
Upper East	85	92	78	2004.9 – 2010.4
Upper West	108	123	97	2005.0 – 2010.6

Table 10 Continued

Place of residence				
Urban	61	59	63	2002.8 – 2011.0
Rural	82	90	77	2006.1 – 2010.6
Wealth status				
Poorest	101	108	91	2005.7 – 2010.5
Poorer	74	79	64	2005.5 – 2101.7
Middle	71	71	70	2005.4 – 2010.6
Richer	59	65	50	2002.6 – 2010.9
Richest	60	61	54	2001.2 – 2011.4
Level of education				
No education	96	109	84	2004.2 – 2010.8
Primary	79	64	95	2005.3 – 2010.8
Secondary	58	69	50	2004.8 – 2010.6
Higher	47	54	45	2008.4 – 2009.8
Total	74	78	68	2006.3 – 2013.1

Source: Computed from GDHS 2014 per 1000 live birth

The under-five mortality rate for women in the rural areas was 82 deaths (90 for males and 77 females) per 1000 live births whereas the infant mortality rate for women in urban areas was 61 deaths (59 for males and 63 females) per 1000 live births (see Table 10).

Also, results from the study showed that concerning the level of education, under-five mortality rate ranged from 47 deaths (54 for males and 45 for females) per 1000 live births among women with higher education (see Table 10) to 96 deaths (100 for males and 84 for females) per 1000 live births among women with no formal education (see Table 10).

Furthermore, results from the study showed that under-five mortality rate by wealth status ranged from 59 deaths (65 for males and 50 for females) per 1000 live births among women with richer wealth status (see Table 10) to 101 deaths (108 for males and 91 for females) per 1000 live births among women with poorest wealth status (see Table 10).

Estimation of Under Five mortality using Palloni-Heligman Variant of the Brass Method

Using the Palloni-Heligman method, Generally, the under-five mortality rate was 78 (83 for males and 71 for females) per 1000 live births (see Table 11). Also, results from the study showed that under-five mortality rate ranged from 44 deaths (40 for males and 53 for females) per 1000 live births among women from the Greater Accra Region to 127 deaths (139 for males and 115 for females) per 1000 live births among women from the Northern Region (see Table 11).

Table 11:Estimation of Under-five mortality using Palloni – Heligman Variant of the Brass method

Background characteristics	Both Sexes	Male	Female	Reference Date
Region				
Western	56	76	44	2002.4 – 2013.3
Central	81	77	85	2008.1 – 2012.0
Greater Accra	44	40	53	2004.6 – 2013.1
Volta	63	64	60	2008.4 – 2013.0
Eastern	69	62	57	2006.3 – 2013.1
Ashanti	90	115	72	2007.8 – 2013.0
Brong Ahafo	65	74	56	2006.6 – 2013.1
Northern	127	139	115	2006.1 – 2013.1
Upper East	89	96	81	2006.7 – 2013.0
Upper West	114	131	101	2006.6 – 2013.1

Table 11 Continued

Place of residence				
Urban	67	69	62	2004.0– 2013.2
Rural	84	91	78	2007.4 – 2013.0
Wealth status				
Poorest	103	108	97	2007.4 – 2013.1
Poorer	75	83	66	2007.1 – 2013.1
Middle	71	72	69	2008.1 – 2013.1
Richer	63	76	50	2004.2 – 2013.2
Richest	65	65	63	2002.3 – 2013.2
Level of education				
No education	103	115	90	2005.6 – 2013.1
Primary	80	68	93	2006.8 – 2013.1
Secondary	59	70	52	2006.4 – 2013.1
Higher	47	48	46	2006.7 – 2012.7

Source: Computed from GDHS 2014 per 1000 live births

The under-five mortality rate for women in the rural areas was 84 deaths (91 for males and 78 females) per 1000 live births whereas the infant mortality rate for women in urban areas was 67 deaths (69 for males and 62 females) per 1000 live births (see Table 11). Also, results from the study showed that, concerning wealth status, under-five mortality rate ranged from 63 deaths (76 for males and 50 for females) per 1000 live births among women with richer wealth status (see Table 11) to 103 deaths (108 for males and 97 for females) per 1000 live births among women with poorest wealth status (see Table 11).

Likewise, findings from the study showed that, regarding the level of education, under-five mortality rate ranged from 47 deaths (48 for males and 46 for females) per 1000 live births among women with higher education (see Table 11) to 103 deaths (115 for males and 90 for females) per 1000 live births among women with no formal education (see Table 11).

Differentials in estimating Under Five mortality (Both sexes) using direct and Indirect methods

Table 12 presents the results of the differentials in the estimation of under-five mortality for both sexes, using the direct and indirect (Trussell and Palloni-Heligman) methods of estimation. The results showed that almost all the estimations using indirect methods were higher than that of the direct methods. Generally, under-five mortality for both sexes was 60/1000 live births, using direct methods, compared to indirect methods of 74/1000 live births and 78/1000 live births for Trussell and Palloni-Heligman methods respectively (See Table 12).

Table 12: Differentials in estimating Under Five mortality (Both sexes) using direct and Indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	56	50	56
Central	69	79	80
Greater Accra	47	43	44
Volta	61	62	63
Eastern	68	65	69
Ashanti	80	88	90
Brong Ahafo	57	62	65
Northern	111	118	127
Upper East	72	83	89
Upper West	92	108	114

Table 12 continued

Place of residence			
Urban	64	61	67
Rural	75	82	84
Wealth status			
Poorest	92	101	103
Poorer	73	74	75
Middle	61	71	71
Richer	55	59	63
Richest	64	60	65
Level of education			
No education	92	96	103
Primary	72	79	80
Secondary	55	58	59
Higher	48	47	47
Total	60	74	78

Source: Computed from GDHS 2014 per 1000 live births

Moreover, women from the Northern Region had the highest share of under-five mortality rates for both sexes, using both the direct (111/1000 live births) and indirect (118/1000 live births and 127/1000 live births using Trussell and Palloni-Heligman respectively) methods of estimation (see Table 12). With regard to the place of residence, women from rural areas had the highest rate of under-five mortality rate for both sexes for both the direct method of estimation (75/1000 live births) and the indirect method of estimation (82/1000 live births for Trussell method and 84/1000 live births for Palloni-Heligman method) (see Table 12).

Also, Table 12 shows that women with the poorest wealth status had the highest share of under-five mortality rates for both sexes, using both the indirect (101/1000 live births and 103/1000 live births for Trussell and Palloni-Heligman methods correspondingly) and direct (92/1000 live births) methods of estimation.

Concerning the level of education, there were some variations in the estimations of direct and indirect methods. Women with no education had the highest share of under-five mortality rates for both sexes, with 92/1000 live births for the direct method of estimation, compared to 96/1000 live births and 103/1000 live births for Trussell and Palloni-Heligman indirect methods respectively (see Table12).

Differences in estimating Under Five mortality (Males) using direct and indirect methods

Table 13 shows the outcomes of the differentials in the estimation of under-five mortality for males, using the Trussell and Palloni-Heligman (indirect) and direct methods of under-five mortality estimation. The results showed that almost all the estimation using indirect methods were higher than that of the direct method. Also, among the indirect methods of estimation, results from the Palloni-Heligman method were higher than those from the Trussell method.

Generally, under-five mortality for males was 67/1000 live births, using direct methods, compared to 78/1000 live births and 83/1000 live births for Trussell and Palloni-Heligman indirect methods respectively (see Table 13). Likewise, women from the Northern Region had the highest rate of under-five mortality rates among males using both the direct (117/1000 live births) and indirect (133/1000 live births and 139/1000 live births using Trussell and Palloni-Heligman respectively) methods of estimation (see Table 13).

Furthermore, women from rural areas had the highest share of under-five mortality rates among males for both the direct method of estimation (83/1000 live births) and the indirect method of estimation (91/1000 live births for Palloni-Heligman method and 90/1000 live births for Trussell method) (see Table 13).

Regarding wealth status, there are some discrepancies in the methods of estimations. Women with richer wealth status (62/1000 live births) were seen to have the lowest share of under-five mortality among males, using the direct method of estimation whereas women with richest wealth status (61/1000 live births) and middle wealth status (72/1000 live births) (see Table 13) were found to have the lowest share of under-five mortality among males using Trussell and the Palloni-Heligman indirect method of under-five mortality estimation respectively.

Table 13: Differences in estimating Under Five mortality (Males) using direct and indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	71	58	76
Central	82	75	78
Greater Accra	50	35	40
Volta	48	63	64
Eastern	65	60	62
Ashanti	95	117	117
Brong Ahafo	76	71	74
Northern	117	133	139
Upper East	77	92	96
Upper West	107	123	131
Place of residence			
Urban	72	59	69
Rural	83	90	91

Table 13 continued

Wealth status			
Poorest	101	108	108
Poorer	82	79	83
Middle	64	71	72
Richer	62	65	76
Richest	71	61	75
Level of education			
No education	106	109	115
Primary	73	64	68
Secondary	60	69	70
Higher	59	54	48
Total	67	78	83

Source: Computed from GDHS 2014 per 1000 live births

Similar results were found concerning the level of education. Women with higher education were found to have the lowest rate of under-five mortality using the indirect methods of estimation (54/1000 live births for Trussell and 48/1000 live births for Palloni-Heligman). Also, women with higher education (59/1000 live births) were seen to have the lowest rate of under-five mortality, using the direct methods of estimation (see Table 13).

Differences in estimating Under Five mortality (Females) using direct and indirect methods

This section presents the results on the differentials in the estimation of under-five mortality among females using the Trussell and Palloni-Heligman (indirect methods) and direct methods of under-five mortality estimation. Generally, under-five mortality for females was 52/1000 live births, using direct methods, compared to 68/1000 live births and 71/1000 live births for Trussell and Palloni-Heligman indirect methods respectively (see Table 14). Also, women from the Northern Region had the highest share of under-five mortality rates among females, using both the direct (104/1000 live births) and indirect (103/1000 live births and 115/1000 live births using Trussell and Palloni-Heligman respectively) methods of estimation (see Table 14).

Additionally, with reference to the place of residence, women from rural areas had the highest rate of under-five mortality rate among females for both the indirect method of estimation (78/1000 live births for Palloni-Heligman and 77/1000 live births for Trussell) and the direct method (67/1000 live births) of under-five mortality estimation (see Table 14).

With regard to wealth status, women with poorest wealth status were found to have the highest share of under-five mortality among females, using the direct (81/1000 live births) and indirect (91/1000 live births for Trussell and 97/1000 live births for Palloni-Heligman) method of under-five mortality estimation (see Table 14).

Table 14: Differentials in estimating Under Five mortality (Females) using direct and indirect methods

Background characteristics	Direct	Indirect	
		Trussell	Palloni – Heligman
Region			
Western	40	40	44
Central	55	85	84
Greater Accra	43	52	53
Volta	77	59	60
Eastern	72	72	76
Ashanti	65	68	69
Brong Ahafo	37	53	56
Northern	104	103	115
Upper East	67	78	81
Upper West	75	97	101

Table 14 continued

Place of residence			
Urban	56	63	62
Rural	67	77	78
Wealth status			
Poorest	81	91	97
Poorer	63	64	66
Middle	57	70	69
Richer	48	50	50
Richest	56	54	63
Level of education			
No education	77	84	90
Primary	71	95	93
Secondary	49	50	52
Higher	38	45	46
Total	52	68	71

Source: Computed from GDHS 2014 per 1000 live births

Similar results were found with regard to the level of education of mothers. Children of women with no education (77/1000 live births) were found to have the highest rate of under-five mortality, using the direct methods of estimation whereas women with primary education (95/1000 live births) were seen to have the highest rate of under-five mortality, using Trussell indirect method of under-five mortality estimation. Children of women with primary education (93/1000 live births) were seen to have the highest rate of under-five mortality using Palloni-Heligman indirect methods of under-five mortality estimation (see Table 14).

Test of Difference for Under five Mortality

This section examines whether there is a significant association between the difference in under-five mortality estimates using direct and indirect techniques. A test of difference was conducted to compare the under-five mortality estimations using direct and indirect techniques (see Appendix D).

There was no significant difference in the under-five mortality estimates with respect to region of residence using both direct and indirect techniques. For example, the under-five mortality estimate for central region was 69/1000 live births with a 95% confidence interval of a lower bound 52/1000 live births and an upper bound of 85/1000 live births using the direct technique. Under-five mortality estimate for central region Trussell technique was 79/1000 live births with a 95% confidence interval of 70/1000 live births and 88/1000 live births. Where as Palloni-Heligman techniques was 80/100 live births with a 95% confidence interval of a lower bound 73/1000 live births and an upper bound of 87/1000 live births (see Appendix D).

Furthermore, it was observed that there was no significant difference in the under-five mortality estimates for place of residence, using direct and indirect techniques. Under five mortality estimate for urban residence was 64/1000 live births (95% confidence interval of 55/1000 and 74/1000 live births) using the direct technique and for the indirect method [61/1000 live births (95% confidence interval of 56/1000 and 66/1000 live births) using Trussell technique and 67/1000 live birth (95% confidence interval of 60/1000 and 74/1000 live births) using Palloni-Heligman technique] (see Appendix D).

Also, it was observed that there was no significant difference in the under-five mortality estimates for education, using direct and indirect techniques. For instance, under five mortality estimates for primary education was 72/1000 (95% confidence interval of 78/1000 and 106/1000) live births using direct technique. Whiles under five mortality for primary education was 79/1000 (95% confidence interval of 62/1000 and 90/1000) live births using Trussell technique and 80/1000 (95% confidence interval lower bound of 57/1000 and upper bound of 103/1000) live births using Palloni-Heligman (see Appendix D).

With reference to wealth status, there was no significant difference in the under-five mortality estimates using both the direct and indirect techniques. For example, the under-five mortality for poorest wealth quintile was 92/1000 live births (95% confidence interval lower bound of 78/1000 and upper bound of 106/1000) using direct technique. Whereas using indirect technique under-five mortality for poorest wealth quintile was 101/1000 live births using Trussell technique and 103/1000 live birth (95% confidence interval lower bound of

93/1000 and upper bound of 113/1000) using Palloni-Heligman (see Appendix D).

A statistically significant association was expected, and this assumption was not confirmed by the study. On this premise, we accept the null hypothesis that there is no significant association between results from Direct and Trussell techniques for under-five mortality. We also accept the null hypothesis that there is no significant association between results from Direct and Palloni-Heligman techniques for under-five mortality. This implies that with estimations of under-five mortality we can use either Trussell or Palloni-Heligman to estimate under-five mortality.

Discussion and Conclusion

Generally, the under-five mortality estimations from the Palloni-Heligman indirect method were higher than that of Trussell and the direct methods. For instance, under-five mortality was 78 per 1000 live births using the Palloni-Heligman method, 74 per 1000 live births using the Trussell method, and 60 live births using direct methods.

Palloni-Heligman technique gives a better estimate than both the Trussell variant of the Brass method and the direct method (Adedini, 2013). The possible explanation is that the Palloni-Heligman technique uses a more robust method of calculation that adds the mean age of childbearing to its calculation. This finding is consistent with studies that found that indirect estimations of infant and under-five estimations were higher than the direct methods (Adetunji, 1996; Chifundo, 2009; Silva, 2012). A plausible explanation will be as a result of data quality errors which may result from misreporting or underreporting.

The direct methods are affected by underreporting, and for it to work well, the data needs to be accurate and complete. It was reported that the 2014 GDHS values for the under-five mortality were underreported (Ghana Statistical Service (GSS), Ghana Health Service (GHS) and ICF International, 2015). The Palloni-Heligman method reveals more realistic and could be used in Ghana. Since results were higher than the direct methods, it could make up for underreporting reported in the 2014 DHS.

Palloni-Heligman variant is based on the United Nations life tables for developing countries which was derived from model life tables from Africa, Latin America, and Asia (INDEPTH Network, 2004). The United Nations life tables for developing countries were developed to fill the void to meet the needs of developing countries. The earlier life tables such as Coale and Demeny life tables did not reflect the issues of developing countries.

The analysis further revealed that under-five mortality for estimations of males was higher than that of females. For instance, under-five mortality for women in rural areas was 75 deaths (83 for males and 67 for females) per 1000 live births using direct methods; 82 deaths (90 for males and 72 for females) per 1000 live births; and 84 deaths (91 for males and 78 for females) per 1000 live births. This finding is consistent with the findings of Adedini (2013). Adenini in his study that explored the contextual determinants of infant and child mortality in Nigeria, found that under-five estimations for males in Nigeria were higher than that of the females. The possible explanation is that, generally, the sex ratio at birth favours the males, but as they advance in age, the females are more likely to survive, compared to males.

Furthermore, the study found that the estimations from the Palloni-Heligma variant of the brass method were higher than those from the Trussell variant and the direct methods. This finding is consistent with the results of a study by Adedini (2013) which looked at the contextual determinants of infant and child mortality in Nigeria.

The study showed that estimations from indirect methods were higher, compared to those from direct estimations. A significant difference was seen in the estimations using indirect and direct techniques. Also, it was observed from the findings that the difference in under-five mortality between direct and indirect techniques was wider for women with the poorest wealth status for both sexes. This gap closes with women who had improved wealth status. For instance, the under-five mortality from women with the poorest wealth status was 92/1000 live births, using the direct technique and 101/1000 and 103/1000 live births using Trussell and Palloni-Heligman, respectively. The difference between the direct and indirect techniques was 9/1000 live births for Trussell and 11/1000 live births for Palloni-Heligman.

However, the difference was closer between direct and indirect techniques for women with richer wealth status for both sexes. The difference between the direct and indirect techniques was 4/1000 live births for Trussell and 8/1000 live births for Palloni-Heligman. This may be attributed to the quality of reporting of infant mortality among women with different wealth status and the robustness of calculating the technique of the indirect method. The indirect method of estimation relies on mathematical functions and mortality patterns (United Nations Population Division, 2003; Moultrie, Dorrington, Hill, Timaeus, & Zaba, 2013). The next chapter, which concludes the thesis, covers a summary that discusses the methodology and the main findings, conclusions, recommendations, and suggestions for further research.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This chapter presents an overview of the study, methods of the study, a summary of the main findings, conclusions, and some recommendations. The focus of the thesis was using indirect methods to estimate demographic indicators, using infant and under-five mortality as a case study, and comparing the results with direct estimates of the same indicators. The core argument is that in a country such as Ghana where data on registered births and deaths are limited, indirect methods provide alternative approaches for estimating demographic indicators from census and survey data which may not be as reliable as full registration data. Direct estimation techniques are the gold standard, but they work well with accurate and reliable data. The indirect technique, inspired by the lack of reliable data in developing countries, use minimum data available such as brief histories of births and deaths from surveys and censuses.

Summary

There are basically two main techniques for estimating demographic indicators, namely direct and indirect estimation techniques. There are three variants of the direct estimation technique for the estimation of mortality rates. These are the vital registration approach, the true cohort life table approach, and the synthetic cohort life table approach. The synthetic cohort life table approach has been adopted by most household surveys such as the World Fertility Survey and the Demographic and Health Survey. Hence, it was used for the study.

The indirect approaches for estimating demographic indicators include United Nations Life Table, Coale, and Demeny Regional Life Tables, United Nations Model Life Tables for developing countries, INDEPTH Model Life Tables for sub – Saharan Africa and the Brass methods. The study used the Trussell and Palloni-Heligman variants of the Brass methods which are based on the Coale and Demeny Regional life tables and the United Nations model life tables for developing countries.

The study sought to examine direct and indirect methods for estimating demographic indicators for Ghana using childhood mortality data. Specifically, the objectives of the study were to estimate childhood mortality using direct methods, estimate childhood mortality using indirect methods, and Test if there are statistically significant differences between the direct and indirect estimates for estimating childhood mortality from survey data. This was done to explain alternative approaches to estimating demographic indicators such as infant and under-five mortality in the face of inadequate and/or unreliable data.

The study was based on data from the 2014 Ghana Demographic and Health Survey (GDHS). GDHS, a nationwide representative survey that has been designed and conducted every five years since 1988. There have been six rounds of the GDHS and focused on child and maternal health (antenatal care, delivery, and post-natal). Designed and using standardised sampling procedures and questionnaires, the surveys provide adequate data to monitor the population situations in the absence of complete vital registration.

GDHS uses a two-stage nationally representative sample. The first is clusters of a sample frame and second, the selection of households systematically from the clusters. The population used for this study was children aged between 0 and 59 months who were either usual residents of the selected households or visitors present in the selected households on the night before the survey. A total number of 14,697 births were sampled from 11,835 households which were derived from 427 clusters.

Data were analysed using STATA version 14 (United Nations Population Division, 2003) and MORTPAK software version 4.3. The direct estimations were done using STATA version 14 and the indirect estimations were carried out using the QFIVE application based on MORTPAK software version 4.3. Two main indirect estimation techniques were used namely, the Trussell and Palloni-Heligman variants of the Brass model. The Trussell variant is based on the Coale-Demeny Life Tables whereas the Palloni - Heligman variant is based on United Nations Life Tables for developing countries. The United Nations developed a step-to-step guide for estimating child mortality in the early 1990s. The guide was based on the principle of the Brass method (Trussell and Palloni-Heligman variants). Results were presented using tables and charts.

The direct estimation technique uses detailed information on birth history such as the date of birth of the child, child's survival status, age of the death of the child in completed months (if dead), and the date of the interview. Mortality rates are estimated using component death probabilities. The indirect estimation technique uses information on the number of children ever born, the number of children born alive who are dead, the female population in their reproductive age group (15-45 years), and the number of births occurring in a given year classified by age group of the mother. These are data that are collected in censuses and surveys in developing countries. Thus indirect estimation techniques require little or summarised information on the birth history of mothers and with mathematical functions based on model life tables, to derive indicators for a country or any part of a country.

The findings from the study showed that infant mortality and under-five mortality were higher using indirect estimation techniques compared with direct estimation techniques. Among the indirect estimation techniques, results were higher using the Palloni-Heligman variant of the Brass method compared to the Trussell Variant. For instance, the infant mortality rate was 41 per 1000 live births using a direct estimation technique, 50 per 1000 live births using Trussell indirect estimation technique, and 57 per 1000 live births using the Palloni-Heligman indirect estimation technique. Also, the under-five mortality rate was 74 deaths per 1000 live births using the Trussell variant estimation technique and 78 deaths per 1000 live births using the Palloni-Heligman variant estimation technique.

Findings showed that the highest level of infant mortality was among children of women from the urban areas based on the direct method, while the indirect estimation techniques showed that rural women had the highest rate of infant mortality. Results from the indirect estimations should be preferable compared to the direct methods because they provide robust approaches to the use of demographic and health survey to derive estimations. The techniques can compensate for the misreporting of events. Thus, in situations where the quality of data is not reliable, results from indirect methods should be preferred.

It was also observed that the difference in infant mortality rate between direct and indirect estimation techniques was greater for children of women with the poorest wealth status. However, the gap declines with improved wealth status of women and this may be attributed to the quality of reporting of infant mortality among children of women with different wealth statuses.

Conclusions

Infant and Under-five mortality rates were higher using indirect techniques compared to direct techniques. The gap in the rates was higher for infant mortality rates as compared to under-five mortality rates. Among the indirect techniques, infant and under-five mortality rates from the Palloni-Heligman variant of the Brass model were a little higher than that from the Trussell variant technique. The gap in the mortality rates was smaller for the under-five mortality rates compared to the infant mortality rates.

It can be concluded that either the Trussell or Palloni-Heligman variants of the Brass Model could be used in the estimation of under-five mortality using DHS data of Ghana. Moreover, the estimations from the two techniques did not vary much. However, the Palloni-Heligman variant of the Brass Model should be preferred in the estimation of infant mortality. Since it uses a more robust method in its estimations, and it is also based on the Model Life Tables from sub-Saharan Africa.

It is also concluded that the difference in the estimations of the direct and indirect (Trussell and Palloni-Heligman variants of the Brass model) estimation techniques were significant. Henceforth, we fail to accept the null hypothesis that there is no significant association between the result from the direct estimation technique and indirect (Trussell and Palloni-Heligman variants of the Brass model) estimation techniques for both infant and under-five mortality.

Recommendations

It is recommended that in a situation where the available data is accurate and reliable, the direct estimation technique should be used. Direct estimations assume that there is available accurate, reliable, and timely data. With inadequate data, indirect estimation technique should be preferred. Indirect methods of estimation use minimum data available and apply it to mathematical functions based on model life tables.

Also, between the Palloni-Heligman and the Trussell versions of the Brass method the Palloni-Heligman version should be used to estimate infant mortality in Ghana. This is because the Palloni-Heligman version is more robust in its calculation and adds mean age of childbearing to its calculation which the Trussell method does not. It is also based on life tables from developing countries, thus, the United Nations Life Tables for developing countries. Whiles the Trussell variant of the Brass model is based on Coale-Demeny Life Tables which were developed from European life tables.

In the estimation of under-five mortality, either the Trussell or Palloni-Heligman version of the Brass model technique could be used. This is due to the fact that there were no significant relationship in the under-five mortality between the direct and indirect techniques (Trussell and Palloni-Heligman). Also, because the results from the study did not differ much and due to the robustness in the calculating demographic indicators using indirect methods.

It is also recommended that vital registration system should strengthened and access to the birth and death registry should be improved. This will aid in the compilation of data for the use of direct methods.

Areas for Further Study

This may be considered for further research:

1. The study used only two types of indirect methods of estimation, thus, the Trussell and Palloni-Heligman variants of the Brass model. It may be worthwhile to conduct a study with other types of indirect methods such as INDEPTH Model Life Tables for sub-Saharan Africa, Zlotnik, and Hill method compared with direct methods. To give more options given the range of data becoming available. Eg. Maternal Health Survey and Census.
2. It will be imperative to examine other types of direct methods and compare them to indirect methods of estimation

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APPENDIX A: APPLICATION OF THE TRUSSELL VARIANT OF THE BRASS METHOD

Table 15: Estimation of infant and under five mortality using the Trussell Variant of the Brass Method for 2014 GDHS (Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.027	2008.8	0.025	0.031
25 – 29	3	0.055	2007.8	0.042	0.061
30 – 34	5	0.077	2007.3	0.052	0.077
35 – 39	10	0.095	2007.1	0.055	0.083
40 – 44	15	0.116	2006.6	0.061	0.093
45 – 49	20	0.167	2004.7	0.077	0.123
Total *				50	74

Source: Computed from GDHS 2014 * per 1000 live births

Table 16: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.028	2008.8	0.025	0.032
25 – 29	3	0.053	2007.8	0.040	0.059
30 – 34	5	0.071	2007.3	0.047	0.071
35 – 39	10	0.084	2007.2	0.048	0.074
40 – 44	15	0.104	2006.7	0.054	0.084
45 – 49	20	0.149	2004.8	0.068	0.109
Total *				45	68

Source: Computed from GDHS 2014 * per 1000 live births

Table 17: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.027	2008.8	0.024	0.030
25 – 29	3	0.055	2007.7	0.043	0.061
30 – 34	5	0.083	2007.2	0.056	0.083
35 – 39	10	0.105	2007.0	0.061	0.091
40 – 44	15	0.127	2006.5	0.068	0.103
45 – 49	20	0.178	2004.6	0.085	0.132
Total *				53	78

Source: Computed from GDHS 2014 * per 1000 live births

Table 18: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Central Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.033	2008.8	0.030	0.039
25 – 29	3	0.061	2008.2	0.046	0.068
30 – 34	5	0.092	2008.1	0.060	0.092
35 – 39	10	0.088	2008.4	0.052	0.077
40 – 44	15	0.119	2008.4	0.062	0.096
45 – 49	20	0.175	2006.5	0.081	0.129
Total*				53	79

Source: Computed from GDHS 2014 * per 1000 live birth

Table 19: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Central Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.1	0.000	0.000
20 – 24	2	0.024	2008.8	0.024	0.031
25 – 29	3	0.094	2008.5	0.063	0.101
30 – 34	5	0.101	2008.9	0.060	0.095
35 – 39	10	0.056	2009.7	0.040	0.059
40 – 44	15	0.120	2010.1	0.055	0.086
45 – 49	20	0.193	2008.3	0.079	0.121
Total*				54	85

Source: Computed from GDHS 2014 * per 1000 live births

Table 20: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Central Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.031	2008.8	0.028	0.035
25 – 29	3	0.039	2007.8	0.033	0.043
30 – 34	5	0.089	2007.3	0.060	0.089
35 – 39	10	0.108	2007.3	0.063	0.094
40 – 44	15	0.123	2006.9	0.066	0.099
45 – 49	20	0.174	2004.9	0.083	0.129
Total *				52	75

Source: Computed from GDHS 2014 * per 1000 live births

Table 21: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Eastern Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.9	0.000	0.000
20 – 24	2	0.040	2009.2	0.035	0.047
25 – 29	3	0.042	2008.1	0.034	0.050
30 – 34	5	0.059	2007.4	0.041	0.058
35 – 39	10	0.098	2007.1	0.056	0.088
40 – 44	15	0.091	2006.4	0.049	0.062
45 – 49	20	0.161	2004.3	0.075	0.107
Total *				45	65

Source: Computed from GDHS 2014 * per 1000 live births

Table 22: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Eastern Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.7	0.000	0.000
20 – 24	2	0.040	2009.0	0.034	0.048
25 – 29	3	0.062	2008.0	0.046	0.069
30 – 34	5	0.078	2007.0	0.051	0.079
35 – 39	10	0.078	2007.5	0.045	0.068
40 – 44	15	0.070	2006.8	0.039	0.057
45 – 49	20	0.126	2004.8	0.059	0.092
Total *				47	72

Source: Computed from GDHS 2014 * per 1000 live births

Table 23: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Eastern Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.039	2008.9	0.035	0.046
25 – 29	3	0.031	2007.7	0.027	0.034
30 – 34	5	0.038	2007.4	0.030	0.038
35 – 39	10	0.123	2007.2	0.070	0.107
40 – 44	15	0.083	2006.7	0.047	0.067
45 – 49	20	0.161	2004.7	0.077	0.119
Total *				42	60

Source: Computed from GDHS 2014 * per 1000 live births

Table 24: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.9	0.000	0.000
20 – 24	2	0.021	2009.1	0.019	0.029
25 – 29	3	0.029	2007.9	0.028	0.034
30 – 34	5	0.056	2006.4	0.044	0.056
35 – 39	10	0.040	2005.6	0.029	0.036
40 – 44	15	0.095	2005.6	0.058	0.076
45 – 49	20	0.200	2003.5	0.107	0.148
Total *				34	43

Source: Computed from GDHS 2014 * per 1000 live births

Table 25: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.0	0.000	0.000
20 – 24	2	0.000	2008.4	0.000	0.000
25 – 29	3	0.042	2008.0	0.033	0.047
30 – 34	5	0.070	2008.3	0.046	0.070
35 – 39	10	0.043	2009.1	0.029	0.039
40 – 44	15	0.134	2009.4	0.067	0.107
45 – 49	20	0.092	2007.6	0.045	0.068
Total *				36	52

Source: Computed from GDHS 2014 * per 1000 live births

Table 26: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.4	0.000	0.000
20 – 24	2	0.030	2009.2	0.027	0.034
25 – 29	3	0.020	2007.0	0.018	0.022
30 – 34	5	0.047	2005.0	0.035	0.047
35 – 39	10	0.028	2003.1	0.028	0.035
40 – 44	15	0.052	2001.3	0.033	0.043
45 – 49	20	0.249	1999.1	0.116	0.285
Total *				27	35

Source: Computed from GDHS 2014 * per 1000 live births

Table 27: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Northern Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.8	0.000	0.000
20 – 24	2	0.037	2009.1	0.032	0.043
25 – 29	3	0.081	2007.9	0.061	0.092
30 – 34	5	0.141	2007.3	0.088	0.141
35 – 39	10	0.140	2007.0	0.076	0.121
40 – 44	15	0.127	2006.3	0.065	0.101
45 – 49	20	0.166	2004.3	0.077	0.123
Total *				75	118

Source: Computed from GDHS 2014 * per 1000 live births

Table 28: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Northern Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.0	0.000	0.000
20 – 24	2	0.047	2009.1	0.039	0.057
25 – 29	3	0.076	2007.5	0.055	0.086
30 – 34	5	0.114	2006.3	0.070	0.114
35 – 39	10	0.127	2005.4	0.068	0.109
40 – 44	15	0.132	2004.3	0.066	0.106
45 – 49	20	0.152	2002.2	0.069	0.111
Total *				64	103

Source: Computed from GDHS 2014 * per 1000 live births

Table 29: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Northern Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.9	0.000	0.000
20 – 24	2	0.023	2009.4	0.021	0.026
25 – 29	3	0.090	2008.5	0.067	0.101
30 – 34	5	0.172	2008.0	0.107	0.172
35 – 39	10	0.146	2007.8	0.081	0.126
40 – 44	15	0.123	2007.2	0.066	0.099
45 – 49	20	0.198	2007.1	0.093	0.147
Total *				85	133

Source: Computed from GDHS 2014 * per 1000 live births

Table 30: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper East Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.013	2009.0	0.011	0.014
25 – 29	3	0.056	2008.0	0.043	0.062
30 – 34	5	0.103	2007.5	0.066	0.103
35 – 39	10	0.095	2007.3	0.055	0.083
40 – 44	15	0.140	2006.8	0.072	0.112
45 – 49	20	0.141	2004.8	0.067	0.104
Total *				55	83

Source: Computed from GDHS 2014 * per 1000 live births

Table 31: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper East Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.1	0.000	0.000
20 – 24	2	0.000	2008.4	0.000	0.000
25 – 29	3	0.040	2007.7	0.032	0.044
30 – 34	5	0.117	2007.6	0.072	0.117
35 – 39	10	0.085	2007.9	0.048	0.074
40 – 44	15	0.121	2007.9	0.061	0.097
45 – 49	20	0.134	2006.1	0.062	0.098
Total *				51	78

Source: Computed from GDHS 2014 * per 1000 live births

Table 32: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper East Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2009.6	0.000	0.000
20 – 24	2	0.014	2007.8	0.013	0.016
25 – 29	3	0.068	2007.1	0.053	0.076
30 – 34	5	0.100	2007.2	0.066	0.100
35 – 39	10	0.117	2007.8	0.067	0.101
40 – 44	15	0.220	2008.1	0.111	0.179
45 – 49	20	0.174	2006.4	0.083	0.129
Total *				62	92

Source: Computed from GDHS 2014 * per 1000 live births

Table 33: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper West Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.060	2008.9	0.050	0.074
25 – 29	3	0.053	2008.0	0.041	0.058
30 – 34	5	0.135	2007.5	0.084	0.135
35 – 39	10	0.152	2007.4	0.082	0.131
40 – 44	15	0.152	2007.0	0.077	0.122
45 – 49	20	0.151	2005.0	0.071	0.111
Total *				69	108

Source: Computed from GDHS 2014 * per 1000 live births

Table 34: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper West Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.8	0.000	0.000
20 – 24	2	0.012	2009.3	0.010	0.013
25 – 29	3	0.064	2008.5	0.048	0.072
30 – 34	5	0.106	2008.2	0.066	0.106
35 – 39	10	0.133	2008.1	0.071	0.114
40 – 44	15	0.151	2007.7	0.074	0.121
45 – 49	20	0.150	2005.7	0.068	0.110
Total *				62	97

Source: Computed from GDHS 2014 * per 1000 live births

Table 35: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Upper West Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.087	2008.5	0.072	0.109
25 – 29	3	0.042	2007.4	0.035	0.047
30 – 34	5	0.176	2006.9	0.110	0.176
35 – 39	10	0.168	2006.8	0.093	0.146
40 – 44	15	0.152	2006.3	0.080	0.123
45 – 49	20	0.152	2004.4	0.073	0.112
Total *				79	123

Source: Computed from GDHS 2014 * per 1000 live births

Table 36: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Volta Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.2	0.000	0.000
20 – 24	2	0.054	2008.5	0.035	0.48
25 – 29	3	0.038	2007.8	0.029	0.038
30 – 34	5	0.059	2007.8	0.041	0.059
35 – 39	10	0.095	2008.2	0.058	0.088
40 – 44	15	0.108	2008.2	0.060	0.092
45 – 49	20	0.063	2006.2	0.034	0.047
Total *				43	62

Source: Computed from GDHS 2014 * per 1000 live births

Table 37: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Volta Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.075	2008.8	0.060	0.095
25 – 29	3	0.031	2008.1	0.026	0.034
30 – 34	5	0.072	2007.9	0.047	0.072
35 – 39	10	0.082	2008.2	0.047	0.072
40 – 44	15	0.000	2008.1	0.000	0.000
45 – 49	20	0.000	2006.2	0.000	0.000
Total *				40	59

Source: Computed from GDHS 2014 * per 1000 live births

Table 38: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Volta Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2009.8	0.000	0.000
20 – 24	2	0.009	2008.0	0.009	0.011
25 – 29	3	0.038	2007.4	0.032	0.042
30 – 34	5	0.048	2007.7	0.036	0.048
35 – 39	10	0.115	2008.4	0.066	0.099
40 – 44	15	0.125	2008.5	0.067	0.101
45 – 49	20	0.107	2006.4	0.053	0.078
Total *				45	63

Source: Computed from GDHS 2014 * per 1000 live births

Table 39: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Western Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.3	0.000	0.000
20 – 24	2	0.021	2009.3	0.019	0.024
25 – 29	3	0.047	2007.6	0.037	0.052
30 – 34	5	0.044	2006.2	0.033	0.044
35 – 39	10	0.061	2005.0	0.039	0.054
40 – 44	15	0.123	2003.6	0.064	0.099
45 – 49	20	0.095	2001.5	0.047	0.070
Total *				36	50

Source: Computed from GDHS 2014 * per 1000 live births

Table 40: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Western Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.0	0.000	0.000
20 – 24	2	0.013	2009.1	0.011	0.015
25 – 29	3	0.030	2007.5	0.025	0.032
30 – 34	5	0.043	2006.4	0.032	0.043
35 – 39	10	0.049	2005.5	0.032	0.044
40 – 44	15	0.122	2004.4	0.062	0.098
45 – 49	20	0.226	2002.3	0.098	0.167
Total *				30	40

Source: Computed from GDHS 2014 * per 1000 live births

Table 41: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Western Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.6	0.000	0.000
20 – 24	2	0.030	2009.7	0.027	0.035
25 – 29	3	0.061	2007.7	0.048	0.068
30 – 34	5	0.045	2006.0	0.034	0.045
35 – 39	10	0.071	2004.3	0.044	0.062
40 – 44	15	0.124	2002.6	0.066	0.100
45 – 49	20	0.000	2000.3	0.000	0.000
Total *				42	58

Source: Computed from GDHS 2014 * per 1000 live births

Table 42: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Ashanti Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.011	2008.8	0.010	0.013
25 – 29	3	0.064	2008.1	0.055	0.072
30 – 34	5	0.081	2008.0	0.057	0.073
35 – 39	10	0.139	2008.2	0.084	0.120
40 – 44	15	0.108	2008.1	0.057	0.076
45 – 49	20	0.204	2006.2	0.093	0.151
Total *				65	88

Source: Computed from GDHS 2014 * per 1000 live births

Table 43: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Ashanti Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.023	2008.8	0.020	0.026
25 – 29	3	0.043	2008.0	0.039	0.048
30 – 34	5	0.046	2007.8	0.036	0.046
35 – 39	10	0.128	2008.0	0.076	0.110
40 – 44	15	0.067	2007.8	0.042	0.055
45 – 49	20	0.113	2005.9	0.054	0.083
Total *				50	68

Source: Computed from GDHS 2014 * per 1000 live births

Table 44: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Ashanti Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2009.7	0.000	0.000
20 – 24	2	0.000	2008.1	0.000	0.000
25 – 29	3	0.085	2007.8	0.064	0.096
30 – 34	5	0.127	2008.3	0.083	0.127
35 – 39	10	0.150	2009.4	0.084	0.130
40 – 44	15	0.120	2009.9	0.065	0.097
45 – 49	20	0.316	2008.2	0.147	0.243
Total *				77	117

Source: Computed from GDHS 2014 * per 1000 live births

Table 45: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Brong Ahafo – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.048	2009.0	0.033	0.044
25 – 29	3	0.063	2008.0	0.045	0.065
30 – 34	5	0.070	2007.6	0.047	0.069
35 – 39	10	0.056	2007.4	0.037	0.052
40 – 44	15	0.130	2007.0	0.070	0.110
45 – 49	20	0.150	2005.0	0.072	0.113
Total *				46	62

Source: Computed from GDHS 2014 * per 1000 live birth

Table 46: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Brong Ahafo – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.7	0.000	0.000
20 – 24	2	0.028	2009.1	0.025	0.033
25 – 29	3	0.035	2008.1	0.029	0.039
30 – 34	5	0.072	2007.6	0.047	0.072
35 – 39	10	0.054	2007.4	0.034	0.048
40 – 44	15	0.075	2006.9	0.041	0.061
45 – 49	20	0.133	2004.9	0.062	0.098
Total *				37	53

Source: Computed from GDHS 2014 * per 1000 live births

Table 47: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Brong Ahafo – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.045	2008.9	0.039	0.054
25 – 29	3	0.079	2008.0	0.060	0.089
30 – 34	5	0.067	2007.5	0.047	0.067
35 – 39	10	0.064	2007.4	0.041	0.056
40 – 44	15	0.196	2007.0	0.100	0.158
45 – 49	20	0.170	2005.0	0.081	0.126
Total *				49	71

Source: Computed from GDHS 2014 * per 1000 live births

Table 48: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Urban – Both sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.0	0.000	0.000
20 – 24	2	0.026	2009.8	0.023	0.026
25 – 29	3	0.042	2007.8	0.034	0.046
30 – 34	5	0.067	2006.7	0.045	0.066
35 – 39	10	0.082	2005.9	0.048	0.071
40 – 44	15	0.099	2004.9	0.054	0.081
45 – 49	20	0.164	2002.8	0.077	0.121
Total*				42	61

Source: Computed from GDHS 2014 * per 1000 live births

Table 49: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Urban - Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.019	2008.8	0.018	0.023
25 – 29	3	0.035	2007.5	0.030	0.042
30 – 34	5	0.056	2006.7	0.040	0.058
35 – 39	10	0.087	2006.2	0.050	0.078
40 – 44	15	0.098	2005.5	0.048	0.073
45 – 49	20	0.105	2003.5	0.045	0.067
Total*				40	59

Source: Computed from GDHS 2014 * per 1000 live births

Table 50: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Urban - Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.1	0.000	0.000
20 – 24	2	0.028	2009.1	0.025	0.031
25 – 29	3	0.045	2007.6	0.037	0.050
30 – 34	5	0.073	2006.4	0.051	0.073
35 – 39	10	0.077	2005.4	0.047	0.067
40 – 44	15	0.107	2004.3	0.059	0.087
45 – 49	20	0.225	2002.2	0.106	0.169
Total*				45	63

Source: Computed from GDHS 2014 * per 1000 live births

Table 51: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Rural – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.032	2009.0	0.028	0.037
25 – 29	3	0.063	2008.2	0.048	0.070
30 – 34	5	0.085	2007.9	0.056	0.085
35 – 39	10	0.106	2008.0	0.060	0.092
40 – 44	15	0.118	2008.0	0.062	0.095
45 – 49	20	0.151	2006.1	0.071	0.111
Total*				55	82

Source: Computed from GDHS 2014 * per 1000 live births

Table 52: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Rural – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.033	2009.0	0.028	0.047
25 – 29	3	0.062	2008.2	0.046	0.073
30 – 34	5	0.086	2008.0	0.055	0.086
35 – 39	10	0.085	2008.2	0.048	0.073
40 – 44	15	0.106	2007.9	0.055	0.086
45 – 49	20	0.145	2005.9	0.066	0.111
Total*				50	77

Source: Computed from GDHS 2014 * per 1000 live births

Table 53: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Rural – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.032	2009.0	0.029	0.045
25 – 29	3	0.065	2008.1	0.051	0.076
30 – 34	5	0.085	2007.8	0.057	0.085
35 – 39	10	0.126	2007.8	0.072	0.109
40 – 44	15	0.129	2007.5	0.069	0.106
45 – 49	20	0.156	2005.5	0.075	0.122
Total*				60	90

Source: Computed from GDHS 2014 * per 1000 live births

Table 54: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (No Education – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.8	0.000	0.000
20 – 24	2	0.034	2009.1	0.030	0.039
25 – 29	3	0.072	2008.0	0.054	0.081
30 – 34	5	0.105	2007.3	0.068	0.105
35 – 39	10	0.119	2006.9	0.066	0.103
40 – 44	15	0.153	2006.3	0.077	0.123
45 – 49	20	0.158	2004.2	0.074	0.116
Total*				63	96

Source: Computed from GDHS 2014 * per 1000 live births

Table 55: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (No Education - Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.1	0.000	0.000
20 – 24	2	0.023	2009.4	0.021	0.027
25 – 29	3	0.065	2008.2	0.048	0.073
30 – 34	5	0.087	2007.3	0.056	0.087
35 – 39	10	0.106	2006.7	0.058	0.092
40 – 44	15	0.135	2005.8	0.067	0.108
45 – 49	20	0.133	2003.6	0.062	0.098
Total*				54	84

Source: Computed from GDHS 2014 * per 1000 live births

Table 56: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (No Education - Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.3	0.000	0.000
20 – 24	2	0.037	2008.6	0.033	0.043
25 – 29	3	0.079	2007.7	0.059	0.088
30 – 34	5	0.125	2007.4	0.081	0.125
35 – 39	10	0.133	2007.5	0.075	0.115
40 – 44	15	0.174	2007.3	0.090	0.140
45 – 49	20	0.187	2005.4	0.088	0.138
Total*				72	109

Source: Computed from GDHS 2014 * per 1000 live births

Table 57: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Primary – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.8	0.000	0.000
20 – 24	2	0.037	2009.2	0.032	0.043
25 – 29	3	0.069	2008.3	0.052	0.078
30 – 34	5	0.075	2007.9	0.050	0.075
35 – 39	10	0.095	2007.8	0.055	0.083
40 – 44	15	0.087	2007.3	0.048	0.070
45 – 49	20	0.161	2005.3	0.075	0.119
Total*				52	79

Source: Computed from GDHS 2014 * per 1000 live births

Table 58: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Primary – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.3	0.000	0.000
20 – 24	2	0.025	2008.9	0.022	0.028
25 – 29	3	0.067	2008.4	0.054	0.083
30 – 34	5	0.102	2008.6	0.067	0.109
35 – 39	10	0.103	2009.2	0.058	0.092
40 – 44	15	0.098	2009.4	0.050	0.077
45 – 49	20	0.153	2007.5	0.060	0.095
Total*				60	95

Source: Computed from GDHS 2014 * per 1000 live births

Table 59: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Primary – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.0	0.000	0.000
20 – 24	2	0.047	2009.2	0.041	0.056
25 – 29	3	0.065	2008.0	0.050	0.072
30 – 34	5	0.043	2007.1	0.033	0.043
35 – 39	10	0.089	2006.6	0.053	0.078
40 – 44	15	0.079	2005.7	0.045	0.064
45 – 49	20	0.184	2003.6	0.087	0.136
Total*				45	64

Source: Computed from GDHS 2014 * per 1000 live births

Table 60: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Secondary – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.023	2008.9	0.023	0.029
25 – 29	3	0.041	2007.7	0.039	0.045
30 – 34	5	0.064	2007.5	0.042	0.060
35 – 39	10	0.079	2007.3	0.046	0.068
40 – 44	15	0.075	2006.8	0.043	0.059
45 – 49	20	0.104	2004.8	0.051	0.106
Total*				42	58

Source: Computed from GDHS 2014 * per 1000 live births

Table 61: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Secondary – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.032	2008.7	0.028	0.037
25 – 29	3	0.039	2007.6	0.031	0.042
30 – 34	5	0.054	2007.1	0.037	0.054
35 – 39	10	0.060	2006.9	0.037	0.053
40 – 44	15	0.064	2006.5	0.037	0.052
45 – 49	20	0.094	2004.5	0.046	0.069
Total*				35	50

Source: Computed from GDHS 2014 * per 1000 live births

Table 62: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Secondary – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.2	0.000	0.000
20 – 24	2	0.016	2008.5	0.015	0.018
25 – 29	3	0.044	2007.7	0.036	0.048
30 – 34	5	0.075	2007.6	0.052	0.075
35 – 39	10	0.097	2007.9	0.057	0.084
40 – 44	15	0.086	2007.8	0.049	0.069
45 – 49	20	0.112	2006.0	0.056	0.081
Total*				48	69

Source: Computed from GDHS 2014 * per 1000 live births

Table 63: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Higher – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2008.4	0.000	0.000
20 – 24	2	0.000	2006.7	0.000	0.000
25 – 29	3	0.019	2006.6	0.019	0.020
30 – 34	5	0.046	2007.8	0.034	0.046
35 – 39	10	0.084	2009.8	0.049	0.074
40 – 44	15	0.051	2011.2	0.032	0.042
45 – 49	20	0.000	2009.8	0.000	0.000
Total*				34	47

Source: Computed from GDHS 2014 * per 1000 live births

Table 64: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Higher – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2009.1	0.000	0.000
20 – 24	2	0.000	2007.2	0.000	0.000
25 – 29	3	0.021	2006.8	0.030	0.042
30 – 34	5	0.021	2007.3	0.014	0.018
35 – 39	10	0.080	2008.5	0.049	0.075
40 – 44	15	0.000	2009.2	0.000	0.000
45 – 49	20	0.000	2007.7	0.000	0.000
Total*				31	45

Source: Computed from GDHS 2014 * per 1000 live births

Table 65: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Higher – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.0	0.000	0.000
20 – 24	2	0.000	2007.8	0.000	0.000
25 – 29	3	0.015	2006.3	0.014	0.016
30 – 34	5	0.075	2005.4	0.052	0.075
35 – 39	10	0.081	2005.0	0.049	0.071
40 – 44	15	0.086	2004.4	0.049	0.070
45 – 49	20	0.000	2002.5	0.000	0.000
Total*				38	54

Source: Computed from GDHS 2014 * per 1000 live births

Table 66: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorest – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.039	2008.9	0.034	0.057
25 – 29	13	0.068	2008.1	0.051	0.080
30 – 34	5	0.117	2007.8	0.074	0.117
35 – 39	10	0.126	2007.9	0.070	0.109
40 – 44	15	0.137	2007.6	0.070	0.112
45 – 49	20	0.162	2005.7	0.076	0.126
Total*				65	101

Source: Computed from GDHS 2014 * per 1000 live births

Table 67: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorest – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.039	2008.9	0.033	0.047
25 – 29	3	0.068	2008.2	0.050	0.076
30 – 34	5	0.107	2008.0	0.067	0.107
35 – 39	10	0.105	2008.3	0.058	0.091
40 – 44	15	0.118	2008.1	0.060	0.095
45 – 49	20	0.120	2006.2	0.056	0.088
Total*				58	91

Source: Computed from GDHS 2014 * per 1000 live births

Table 68: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorest – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.039	2008.9	0.035	0.046
25 – 29	3	0.064	2008.3	0.050	0.072
30 – 34	5	0.126	2008.3	0.081	0.126
35 – 39	10	0.147	2008.7	0.082	0.127
40 – 44	15	0.151	2008.6	0.079	0.122
45 – 49	20	0.206	2006.7	0.097	0.153
Total*				71	108

Source: Computed from GDHS 2014 * per 1000 live births

Table 69: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorer – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.7	0.000	0.000
20 – 24	2	0.043	2009.1	0.037	0.062
25 – 29	3	0.060	2008.3	0.046	0.072
30 – 34	5	0.064	2007.9	0.044	0.065
35 – 39	10	0.095	2007.9	0.055	0.084
40 – 44	15	0.126	2007.5	0.065	0.103
45 – 49	20	0.145	2005.5	0.068	0.112
Total*				48	74

Source: Computed from GDHS 2014 * per 1000 live births

Table 70: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorer – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.043	2009.1	0.036	0.052
25 – 29	3	0.047	2008.4	0.040	0.052
30 – 34	5	0.060	2008.1	0.040	0.060
35 – 39	10	0.092	2008.3	0.048	0.080
40 – 44	15	0.098	2008.0	0.049	0.079
45 – 49	20	0.140	2006.0	0.070	0.103
Total*				43	64

Source: Computed from GDHS 2014 * per 1000 live births

Table 71: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Poorer – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.5	0.000	0.000
20 – 24	2	0.044	2008.9	0.038	0.047
25 – 29	3	0.070	2008.1	0.054	0.079
30 – 34	5	0.067	2007.9	0.047	0.068
35 – 39	10	0.097	2008.1	0.057	0.090
40 – 44	15	0.150	2007.9	0.078	0.131
45 – 49	20	0.148	2006.0	0.071	0.131
Total*				53	79

Source: Computed from GDHS 2014 * per 1000 live births

Table 72: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Middle – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.2	0.000	0.000
20 – 24	2	0.017	2008.6	0.016	0.020
25 – 29	3	0.055	2008.0	0.042	0.061
30 – 34	5	0.066	2008.1	0.045	0.066
35 – 39	10	0.099	2008.5	0.057	0.086
40 – 44	15	0.109	2008.6	0.058	0.088
45 – 49	20	0.149	2006.7	0.070	0.102
Total*				48	71

Source: Computed from GDHS 2014 * per 1000 live births

Table 73: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Middle – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.4	0.000	0.000
20 – 24	2	0.016	2009.1	0.014	0.018
25 – 29	3	0.059	2008.7	0.044	0.066
30 – 34	5	0.073	2008.8	0.048	0.073
35 – 39	10	0.083	2009.4	0.048	0.073
40 – 44	15	0.115	2009.4	0.058	0.092
45 – 49	20	0.124	2007.5	0.058	0.092
Total*				47	70

Source: Computed from GDHS 2014 * per 1000 live births

Table 74: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Middle – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.6	0.000	0.000
20 – 24	2	0.015	2009.0	0.018	0.021
25 – 29	3	0.049	2008.1	0.039	0.053
30 – 34	5	0.059	2007.7	0.044	0.062
35 – 39	10	0.130	2007.7	0.066	0.099
40 – 44	15	0.122	2007.3	0.057	0.084
45 – 49	20	0.155	2005.4	0.088	0.37
Total*				50	71

Source: Computed from GDHS 2014 * per 1000 live births

Table 75: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richer – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.9	0.000	0.000
20 – 24	2	0.030	2009.0	0.027	0.034
25 – 29	3	0.039	2007.5	0.032	0.042
30 – 34	5	0.064	2006.6	0.046	0.064
35 – 39	10	0.081	2005.9	0.048	0.071
40 – 44	15	0.075	2004.9	0.043	0.061
45 – 49	20	0.136	2002.6	0.064	0.100
Total*				42	59

Source: Computed from GDHS 2014 * per 1000 live births

Table 76: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richer – Female)

Age group of mothers	Age X	Probability of dying by age x	Referenc e date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2010.3	0.000	0.000
20 – 24	2	0.017	2008.5	0.020	0.020
25 – 29	3	0.029	2007.5	0.024	0.031
30 – 34	5	0.064	2007.1	0.043	0.064
35 – 39	10	0.062	2007.2	0.038	0.054
40 – 44	15	0.097	2006.8	0.051	0.078
45 – 49	20	0.183	2005.0	0.082	0.135
Total*				34	50

Source: Computed from GDHS 2014 * per 1000 live births

Table 77: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richer – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.7	0.000	0.000
20 – 24	2	0.037	2009.6	0.033	0.043
25 – 29	3	0.046	2007.5	0.038	0.051
30 – 34	5	0.063	2005.5	0.045	0.063
35 – 39	10	0.094	2003.6	0.056	0.082
40 – 44	15	0.061	2001.7	0.037	0.049
45 – 49	20	0.119	1999.3	0.059	0.086
Total*				46	65

Source: Computed from GDHS 2014 * per 1000 live births

Table 78: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richest – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.4	0.000	0.000
20 – 24	2	0.000	2009.0	0.000	0.000
25 – 29	3	0.050	2007.3	0.037	0.056
30 – 34	5	0.058	2005.8	0.041	0.061
35 – 39	10	0.065	2004.6	0.043	0.062
40 – 44	15	0.074	2003.3	0.037	0.051
45 – 49	20	0.157	2001.2	0.100	0.172
Total*				41	60

Source: Computed from GDHS 2014 * per 1000 live births

Table 79: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richest – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2011.9	0.000	0.000
20 – 24	2	0.000	2009.8	0.000	0.000
25 – 29	3	0.048	2007.6	0.044	0.053
30 – 34	5	0.045	2005.5	0.032	0.045
35 – 39	10	0.075	2003.5	0.044	0.065
40 – 44	15	0.041	2001.4	0.026	0.035
45 – 49	20	0.086	1999.0	0.043	0.064
Total*				40	54

Source: Computed from GDHS 2014 * per 1000 live births

Table 80: Estimation of infant and under five mortality using Trussell Variant of the Brass Method for 2014 GDHS (Richest – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2009.5	0.000	0.000
20 – 24	2	0.000	2007.5	0.000	0.000
25 – 29	3	0.052	2006.6	0.041	0.061
30 – 34	5	0.075	2006.6	0.048	0.071
35 – 39	10	0.052	2007.1	0.037	0.050
40 – 44	15	0.086	2007.3	0.045	0.065
45 – 49	20	0.330	2005.6	0.205	0.335
Total*				42	61

Source: Computed from GDHS 2014 * per 1000 live births

APPENDIX B: APPLICATION OF THE PALLONI – HELIGMAN VARIANT OF THE BRASS METHOD

Table 81: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by 5
15 – 19	1	0.005	2013.1	0.005	0.006
20 – 24	2	0.042	2009.7	0.038	0.048
25 – 29	3	0.062	2008.0	0.050	0.067
30 – 34	5	0.080	2008.0	0.059	0.080
35 – 39	10	0.094	2009.1	0.063	0.087
40 – 44	15	0.111	2009.4	0.070	0.098
45 – 49	20	0.170	2006.3	0.093	0.137
Total *				57	78

Source: Computed from GDHS 2014 * per 1000 live births

Table 82: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by 5
15 – 19	1	0.002	2013.0	0.002	0.003
20 – 24	2	0.043	2009.6	0.038	0.049
25 – 29	3	0.060	2008.0	0.047	0.064
30 – 34	5	0.073	2008.1	0.053	0.073
35 – 39	10	0.083	2009.1	0.055	0.077
40 – 44	15	0.100	2009.4	0.062	0.088
45 – 49	20	0.151	2006.4	0.080	0.122
Total *				52	71

Source: Computed from GDHS 2014 * per 1000 live births

Table 83: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.007	2013.1	0.007	0.008
20 – 24	2	0.042	2009.6	0.038	0.047
25 – 29	3	0.062	2007.9	0.052	0.067
30 – 34	5	0.087	2007.9	0.065	0.087
35 – 39	10	0.104	2009.0	0.072	0.096
40 – 44	15	0.123	2009.3	0.079	0.108
45 – 49	20	0.182	200.2	0.104	0.148
Total *				63	83

Source: Computed from GDHS 2014 * per 1000 live births

Table 84: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Ashanti Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.017	2009.7	0.015	0.019
25 – 29	3	0.071	2008.2	0.057	0.077
30 – 34	5	0.073	2008.7	0.054	0.073
35 – 39	10	0.131	2010.2	0.086	0.120
40 – 44	15	0.087	2010.8	0.057	0.077
45 – 49	20	0.199	2008.0	0.106	0.160
Total *				67	90

Source: Computed from GDHS 2014 * per 1000 live births

Table 85: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Ashanti Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.035	2009.7	0.031	0.039
25 – 29	3	0.048	2008.2	0.039	0.051
30 – 34	5	0.46	2008.6	0.036	0.046
35 – 39	10	0.120	2010.0	0.074	0.110
40 – 44	15	0.061	2010.6	0.042	0.055
45 – 49	20	0.110	2007.7	0.061	0.091
Total *				50	69

Source: Computed from GDHS 2014 * per 1000 live births

Table 86: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Ashanti Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2012.9	0.000	0.000
20 – 24	2	0.000	2009.1	0.000	0.000
25 – 29	3	0.093	2007.9	0.074	0.101
30 – 34	5	0.123	2009.2	0.89	0.123
35 – 39	10	0.136	2011.8	0.090	0.125
40 – 44	15	0.107	2013.2	0.070	0.094
45 – 49	20	0.300	2010.6	0.160	0.243
Total *				84	117

Source: Computed from GDHS 2014 * per 1000 live births

Table 87: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Brong Ahafo Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.012	2013.1	0.012	0.015
20 – 24	2	0.056	2009.8	0.049	0.064
25 – 29	3	0.065	2008.2	0.052	0.070
30 – 34	5	0.072	2008.3	0.053	0.072
35 – 39	10	0.058	2009.3	0.042	0.054
40 – 44	15	0.130	2009.6	0.080	0.114
45 – 49	20	0.155	2006.6	0.086	0.125
Total *				49	65

Source: Computed from GDHS 2014 * per 1000 live births

Table 88: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Brong Ahafo Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.024	2013.1	0.024	0.030
20 – 24	2	0.041	2009.9	0.036	0.047
25 – 29	3	0.040	2008.3	0.033	0.042
30 – 34	5	0.075	2008.3	0.054	0.075
35 – 39	10	0.053	2009.2	0.038	0.050
40 – 44	15	0.072	2009.4	0.048	0.065
45 – 49	20	0.135	2000.4	0.074	0.110
Total *				42	56

Source: Computed from GDHS 2014 * per 1000 live births

Table 89: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Brong Ahafo Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.008	2013.1	0.008	0.010
20 – 24	2	0.069	2009.8	0.060	0.079
25 – 29	3	0.089	2008.1	0.071	0.096
30 – 34	5	0.069	2008.3	0.053	0.069
35 – 39	10	0.063	2009.3	0.046	0.058
40 – 44	15	0.189	2009.6	0.113	0.162
45 – 49	20	0.171	2006.6	0.099	0.139
Total *				57	74

Source: Computed from GDHS 2014 * per 1000 live births

Table 90: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Central Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.008	2013.0	0.008	0.009
20 – 24	2	0.051	2009.7	0.045	0.059
25 – 29	3	0.067	2008.3	0.053	0.073
30 – 34	5	0.091	2008.8	0.066	0.091
35 – 39	10	0.081	2010.4	0.056	0.075
40 – 44	15	0.107	2011.1	0.068	0.094
45 – 49	20	0.167	2008.3	0.092	0.135
Total *				58	80

Source: Computed from GDHS 2014 * per 1000 live births

Table 91: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Central Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.041	2009.6	0.036	0.046
25 – 29	3	0.095	2008.5	0.071	0.104
30 – 34	5	0.091	2009.6	0.063	0.091
35 – 39	10	0.060	2011.8	0.042	0.056
40 – 44	15	0.093	2013.0	0.058	0.082
45 – 49	20	0.164	2010.4	0.086	0.131
Total *				59	84

Source: Computed from GDHS 2014 *per 1000 live births

Table 92: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Central Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.028	2013.1	0.040	0.051
20 – 24	2	0.048	2009.6	0.043	0.054
25 – 29	3	0.044	2008.0	0.038	0.047
30 – 34	5	0.091	2008.1	0.068	0.091
35 – 39	10	0.102	2009.3	0.070	0.095
40 – 44	15	0.114	2009.6	0.074	0.100
45 – 49	20	0.170	2006.6	0.099	0.139
Total *				59	78

Source: Computed from GDHS 2014 * per 1000 live births

Table 93: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Eastern Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.060	2009.8	0.051	0.068
25 – 29	3	0.051	2008.1	0.042	0.055
30 – 34	5	0.060	2008.2	0.046	0.060
35 – 39	10	0.099	2009.1	0.066	0.092
40 – 44	15	0.074	2009.3	0.050	0.066
45 – 49	20	0.147	2006.3	0.083	0.120
Total *				51	69

Source: Computed from GDHS 2014 * per 1000 live births

Table 94: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Eastern Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.060	2009.8	0.051	0.070
25 – 29	3	0.069	2008.2	0.054	0.075
30 – 34	5	0.081	2008.2	0.058	0.081
35 – 39	10	0.076	2009.2	0.052	0.071
40 – 44	15	0.067	2009.4	0.045	0.060
45 – 49	20	0.126	2006.4	0.070	0.103
Total *				57	76

Source: Computed from GDHS 2014 * per 1000 live births

Table 95: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Eastern Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.059	2009.8	0.052	0.067
25 – 29	3	0.035	2008.1	0.030	0.037
30 – 34	5	0.039	2008.1	0.032	0.039
35 – 39	10	0.121	2009.1	0.081	0.111
40 – 44	15	0.080	2009.3	0.054	0.071
45 – 49	20	0.163	2006.3	0.095	0.133
Total *				48	62

Source: Computed from GDHS 2014 * per 1000 live births

Table 96: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.024	2009.5	0.022	0.035
25 – 29	3	0.027	2007.5	0.028	0.035
30 – 34	5	0.059	2007.2	0.045	0.059
35 – 39	10	0.039	2007.8	0.030	0.038
40 – 44	15	0.065	2007.9	0.059	0.080
45 – 49	20	0.162	2004.6	0.108	0.163
Total *				35	44

Source: Computed from GDHS 2014 * per 1000 live births

Table 97: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2012.9	0.000	0.000
20 – 24	2	0.000	2008.9	0.000	0.000
25 – 29	3	0.029	2007.5	0.038	0.049
30 – 34	5	0.064	2008.6	0.049	0.067
35 – 39	10	0.047	2011.1	0.034	0.044
40 – 44	15	0.074	2012.6	0.070	0.102
45 – 49	20	0.071	2009.9	0.052	0.072
Total *				41	53

Source: Computed from GDHS 2014 * per 1000 live births

Table 98: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Greater Accra Region – Males)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.3	0.000	0.000
20 – 24	2	0.046	2009.6	0.041	0.052
25 – 29	3	0.025	2007.5	0.022	0.027
30 – 34	5	0.055	2006.6	0.043	0.055
35 – 39	10	0.031	2006.4	0.025	0.039
40 – 44	15	0.057	2005.7	0.040	0.051
45 – 49	20	0.282	2002.1	0.152	0.229
Total *				30	40

Source: Computed from GDHS 2014 * per 1000 live births

Table 99: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Northern Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.052	2009.8	0.045	0.059
25 – 29	3	0.094	2008.1	0.073	0.103
30 – 34	5	0.152	2008.1	0.102	0.152
35 – 39	10	0.139	2009.0	0.087	0.127
40 – 44	15	0.124	2009.1	0.077	0.109
45 – 49	20	0.183	2006.1	0.099	0.148
Total *				87	127

Source: Computed from GDHS 2014 * per 1000 live births

Table 100: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Northern Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.2	0.000	0.000
20 – 24	2	0.070	2009.9	0.059	0.083
25 – 29	3	0.089	2007.8	0.067	0.097
30 – 34	5	0.125	2007.1	0.083	0.125
35 – 39	10	0.134	2007.2	0.081	0.122
40 – 44	15	0.137	2006.7	0.079	0.119
45 – 49	20	0.164	2003.4	0.086	0.132
Total *				77	115

Source: Computed from GDHS 2014 * per 1000 live births

Table 101: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Northern Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.032	2010.1	0.029	0.036
25 – 29	3	0.099	2008.6	0.079	0.107
30 – 34	5	0.178	2008.6	0.122	0.178
35 – 39	10	0.144	2009.5	0.094	0.132
40 – 44	15	0.119	2009.5	0.077	0.105
45 – 49	20	0.202	2006.6	0.114	0.164
Total *				98	139

Source: Computed from GDHS 2014 * per 1000 live births

Table 102: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper East Region – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.018	2009.5	0.017	0.020
25 – 29	3	0.064	2007.8	0.051	0.068
30 – 34	5	0.110	2008.0	0.077	0.110
35 – 39	10	0.095	2009.2	0.064	0.088
40 – 44	15	0.161	2009.7	0.094	0.139
45 – 49	20	0.152	2006.7	0.085	0.123
Total *				64	89

Source: Computed from GDHS 2014 * per 1000 live births

Table 103: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper East Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.000	2009.4	0.000	0.000
25 – 29	3	0.045	2007.8	0.037	0.048
30 – 34	5	0.120	2008.4	0.080	0.120
35 – 39	10	0.082	2010.1	0.055	0.076
40 – 44	15	0.115	2010.9	0.069	0.101
45 – 49	20	0.135	2008.1	0.074	0.110
Total *				57	81

Source: Computed from GDHS 2014 * per 1000 live births

Table 104: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper East Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2012.9	0.000	0.000
20 – 24	2	0.028	2008.9	0.026	0.031
25 – 29	3	0.078	2007.2	0.063	0.084
30 – 34	5	0.102	2008.1	0.075	0.102
35 – 39	10	0.111	2010.3	0.076	0.102
40 – 44	15	0.205	2011.6	0.122	0.178
45 – 49	20	0.173	2008.8	0.100	0.141
Total *				71	96

Source: Computed from GDHS 2014 * per 1000 live births

Table 105: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper West Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.090	2009.8	0.076	0.107
25 – 29	3	0.059	2008.1	0.048	0.064
30 – 34	5	0.140	2008.3	0.095	0.140
35 – 39	10	0.149	2009.3	0.093	0.137
40 – 44	15	0.146	2009.6	0.087	0.127
45 – 49	20	0.154	2006.6	0.086	0.125
Total *				79	114

Source: Computed from GDHS 2014 * per 1000 live births

Table 106: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper West Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.016	2010.0	0.014	0.018
25 – 29	3	0.071	2008.6	0.055	0.077
30 – 34	5	0.108	2008.8	0.073	0.108
35 – 39	10	0.128	2009.9	0.078	0.117
40 – 44	15	0.144	2010.1	0.082	0.124
45 – 49	20	0.151	2007.2	0.080	0.121
Total *				69	101

Source: Computed from GDHS 2014 * per 1000 live births

Table 107: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Upper West Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.144	2009.5	0.119	0.173
25 – 29	3	0.049	2007.7	0.040	0.052
30 – 34	5	0.186	2007.7	0.127	0.186
35 – 39	10	0.168	2008.8	0.108	0.154
40 – 44	15	0.149	2009.2	0.093	0.130
45 – 49	20	0.157	2006.1	0.092	0.128
Total *				92	131

Source: Computed from GDHS 2014 * per 1000 live births

Table 108: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Volta Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.005	2013.0	0.005	0.007
20 – 24	2	0.065	2009.4	0.056	0.075
25 – 29	3	0.039	2008.0	0.033	0.041
30 – 34	5	0.059	2008.6	0.045	0.059
35 – 39	10	0.095	2010.4	0.064	0.088
40 – 44	15	0.106	2011.2	0.067	0.093
45 – 49	20	0.063	2008.4	0.041	0.053
Total *				47	63

Source: Computed from GDHS 2014 * per 1000 live births

Table 109: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Volta Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.015	2013.0	0.015	0.018
20 – 24	2	0.115	2009.7	0.091	0.142
25 – 29	3	0.035	2008.2	0.029	0.037
30 – 34	5	0.072	2008.7	0.052	0.072
35 – 39	10	0.078	2010.2	0.052	0.072
40 – 44	15	0.000	2010.8	0.000	0.000
45 – 49	20	0.000	2008.0	0.000	0.000
Total *				44	60

Source: Computed from GDHS 2014 * per 1000 live births

Table 110: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Volta Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.016	2009.2	0.015	0.018
25 – 29	3	0.043	2007.7	0.036	0.045
30 – 34	5	0.048	2008.6	0.038	0.048
35 – 39	10	0.108	2010.6	0.074	0.100
40 – 44	15	0.115	2011.7	0.075	0.101
45 – 49	20	0.105	2008.9	0.065	0.086
Total *				49	64

Source: Computed from GDHS 2014 * per 1000 live births

Table 111: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Western Region – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.020	2013.3	0.020	0.025
20 – 24	2	0.030	2010.1	0.027	0.034
25 – 29	3	0.055	2007.9	0.045	0.059
30 – 34	5	0.049	2006.9	0.038	0.049
35 – 39	10	0.065	2006.6	0.046	0.060
40 – 44	15	0.127	2005.9	0.078	0.111
45 – 49	20	0.103	2002.4	0.062	0.86
Total *				43	56

Source: Computed from GDHS 2014 * per 1000 live births

Table 112: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Western Region – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.2	0.000	0.000
20 – 24	2	0.020	2009.9	0.018	0.022
25 – 29	3	0.035	2007.8	0.029	0.037
30 – 34	5	0.047	2007.1	0.036	0.047
35 – 39	10	0.051	2007.3	0.037	0.048
40 – 44	15	0.123	2006.9	0.073	0.107
45 – 49	20	0.028	2003.5	0.114	0.187
Total *				34	44

Source: Computed from GDHS 2014 * per 1000 live births

Table 113: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Western Region – Males)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.068	2013.3	0.068	0.091
20 – 24	2	0.042	2010.4	0.037	0.047
25 – 29	3	0.072	2008.0	0.059	0.077
30 – 34	5	0.051	2006.6	0.040	0.051
35 – 39	10	0.078	2005.8	0.055	0.072
40 – 44	15	0.131	2004.5	0.084	0.115
45 – 49	20	0.000	2001.0	0.000	0.000
Total *				51	76

Source: Computed from GDHS 2014 * per 1000 live births

Table 114: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Urban – Both sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.005	2013.2	0.005	0.010
20 – 24	2	0.038	2010.0	0.034	0.042
25 – 29	3	0.048	2008.0	0.040	0.051
30 – 34	5	0.070	2007.4	0.052	0.071
35 – 39	10	0.084	2007.7	0.058	0.078
40 – 44	15	0.100	2007.3	0.064	0.088
45 – 49	20	0.174	2004.0	0.095	0.140
Total *				50	67

Source: Computed from GDHS 2014 * per 1000 live births

Table 115: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Urban - Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.010	2013.1	0.010	0.013
20 – 24	2	0.030	2009.9	0.026	0.033
25 – 29	3	0.043	2007.9	0.035	0.046
30 – 34	5	0.060	2007.9	0.045	0.060
35 – 39	10	0.087	2008.6	0.057	0.081
40 – 44	15	0.086	2008.6	0.055	0.076
45 – 49	20	0.091	2005.5	0.055	0.076
Total*				46	62

Source: Computed from GDHS 2014 per 1000 live births

Table 116: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Urban - Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.008	2013.2	0.000	0.000
20 – 24	2	0.056	2009.9	0.036	0.046
25 – 29	3	0.048	2007.8	0.042	0.056
30 – 34	5	0.083	2007.1	0.056	0.078
35 – 39	10	0.079	2007.2	0.054	0.074
40 – 44	15	0.104	2006.7	0.064	0.092
45 – 49	20	0.228	2003.4	0.111	0.192
Total*				53	69

Source: Computed from GDHS 2014 * per 1000 live births

Table 117: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Rural – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.005	2013.0	0.005	0.006
20 – 24	2	0.048	2009.8	0.042	0.054
25 – 29	3	0.069	2008.3	0.055	0.074
30 – 34	5	0.085	2008.6	0.062	0.085
35 – 39	10	0.099	2009.9	0.066	0.091
40 – 44	15	0.108	2010.3	0.068	0.095
45 – 49	20	0.147	2007.4	0.082	0.119
Total*				61	84

Source: Computed from GDHS 2014 * per 1000 live births

Table 118: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Rural - Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.049	2009.8	0.042	0.056
25 – 29	3	0.069	2008.3	0.054	0.074
30 – 34	5	0.086	2008.7	0.060	0.086
35 – 39	10	0.079	2010.1	0.053	0.073
40 – 44	15	0.097	2010.5	0.060	0.085
45 – 49	20	0.140	2007.7	0.076	0.114
Total*				56	78

Source: Computed from GDHS 2014 * per 1000 live births

Table 119: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Rural - Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.006	2013.0	0.006	0.009
20 – 24	2	0.043	2009.6	0.038	0.053
25 – 29	3	0.074	2008.1	0.059	0.077
30 – 34	5	0.090	2008.6	0.064	0.085
35 – 39	10	0.123	2010.1	0.080	0.109
40 – 44	15	0.134	2010.7	0.077	0.104
45 – 49	20	0.170	2007.8	0.089	0.124
Total*				70	91

Source: Computed from GDHS 2014 * per 1000 live births

Table 120: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (No Education – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.049	2009.9	0.043	0.059
25 – 29	3	0.082	2008.2	0.064	0.089
30 – 34	5	0.111	2008.0	0.078	0.111
35 – 39	10	0.119	2008.7	0.077	0.110
40 – 44	15	0.150	2008.7	0.089	0.131
45 – 49	20	0.164	2005.6	0.090	0.132
Total*				73	103

Source: Computed from GDHS 2014 * per 1000 live births

Table 121: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (No Education - Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.2	0.000	0.000
20 – 24	2	0.032	2010.2	0.028	0.036
25 – 29	3	0.076	2008.4	0.057	0.079
30 – 34	5	0.095	2008.0	0.064	0.093
35 – 39	10	0.108	2008.3	0.068	0.099
40 – 44	15	0.135	2008.0	0.078	0.117
45 – 49	20	0.165	2004.8	0.076	0.113
Total*				63	90

Source: Computed from GDHS 2014 * per 1000 live births

Table 122: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (No Education - Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.060	2009.5	0.052	0.068
25 – 29	3	0.089	2007.9	0.071	0.096
30 – 34	5	0.129	2008.2	0.093	0.129
35 – 39	10	0.130	2009.6	0.087	0.120
40 – 44	15	0.166	2010.2	0.102	0.145
45 – 49	20	0.189	2007.3	0.108	0.154
Total*				84	115

Source: Computed from GDHS 2014 * per 1000 live births

Table 123: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Primary – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.004	2013.1	0.004	0.005
20 – 24	2	0.043	2010.0	0.046	0.061
25 – 29	3	0.071	2008.4	0.061	0.083
30 – 34	5	0.070	2008.6	0.056	0.075
35 – 39	10	0.096	2009.6	0.061	0.083
40 – 44	15	0.086	2009.7	0.053	0.071
45 – 49	20	0.171	2006.8	0.088	0.128
Total*				59	80

Source: Computed from GDHS 2014 * per 1000 live births

Table 124: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Primary – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.037	2009.7	0.033	0.042
25 – 29	3	0.080	2008.5	0.061	0.087
30 – 34	5	0.105	2009.4	0.071	0.105
35 – 39	10	0.095	2011.2	0.062	0.088
40 – 44	15	0.085	2012.1	0.054	0.075
45 – 49	20	0.121	2009.4	0.068	0.099
Total*				65	93

Source: Computed from GDHS 2014 * per 1000 live births

Table 125: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Primary – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.011	2013.2	0.008	0.010
20 – 24	2	0.070	2010.0	0.059	0.078
25 – 29	3	0.073	2008.2	0.060	0.079
30 – 34	5	0.045	2007.9	0.036	0.045
35 – 39	10	0.088	2008.3	0.062	0.081
40 – 44	15	0.076	2008.1	0.052	0.067
45 – 49	20	0.185	2004.9	0.106	0.151
Total*				52	68

Source: Computed from GDHS 2014 * per 1000 live births

Table 126: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Secondary – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.003	2013.1	0.003	0.004
20 – 24	2	0.038	2009.8	0.034	0.043
25 – 29	3	0.047	2008.1	0.038	0.049
30 – 34	5	0.065	2008.2	0.046	0.061
35 – 39	10	0.075	2009.2	0.051	0.068
40 – 44	15	0.070	2009.4	0.045	0.059
45 – 49	20	0.102	2006.4	0.079	0.113
Total*				45	59

Source: Computed from GDHS 2014 * per 1000 live births

Table 127: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Secondary – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.004	2013.1	0.004	0.007
20 – 24	2	0.051	2009.6	0.044	0.057
25 – 29	3	0.044	2007.8	0.036	0.042
30 – 34	5	0.055	2007.9	0.042	0.054
35 – 39	10	0.055	2009.0	0.041	0.054
40 – 44	15	0.059	2009.3	0.041	0.053
45 – 49	20	0.091	2006.2	0.056	0.091
Total*				40	52

Source: Computed from GDHS 2014 * per 1000 live births

Table 128: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Secondary – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.003	2013.0	0.003	0.003
20 – 24	2	0.027	2009.4	0.024	0.029
25 – 29	3	0.049	2007.8	0.041	0.052
30 – 34	5	0.075	2008.4	0.057	0.075
35 – 39	10	0.091	2010.1	0.064	0.084
40 – 44	15	0.78	2010.8	0.053	0.069
45 – 49	20	0.109	2008.0	0.067	0.089
Total*				54	70

Source: Computed from GDHS 2014 * per 1000 live births

Table 129: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Higher – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2012.7	0.000	0.000
20 – 24	2	0.000	2008.0	0.000	0.000
25 – 29	3	0.021	2006.7	0.019	0.027
30 – 34	5	0.043	2008.9	0.035	0.045
35 – 39	10	0.072	2008.9	0.050	0.068
40 – 44	15	0.042	2007.6	0.031	0.038
45 – 49	20	0.000	20007.2	0.000	0.000
Total*				35	47

Source: Computed from GDHS 2014 * per 1000 live births

Table 130: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Higher – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2012.8	0.000	0.000
20 – 24	2	0.000	2008.5	0.000	0.000
25 – 29	3	0.071	2007.0	0.035	0.046
30 – 34	5	0.043	2008.3	0.014	0.017
35 – 39	10	0.077	2011.3	0.052	0.071
40 – 44	15	0.000	2013.2	0.000	0.000
45 – 49	20	0.000	2010.5	0.000	0.000
Total*				34	46

Source: Computed from GDHS 2014 * per 1000 live births

Table 131: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Higher – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.000	2009.0	0.000	0.000
25 – 29	3	0.020	2006.3	0.018	0.021
30 – 34	5	0.071	2005.6	0.053	0.071
35 – 39	10	0.124	2006.0	0.041	0.051
40 – 44	15	0.126	2006.0	0.080	0.109
45 – 49	20	0.000	2002.4	0.000	0.000
Total*				37	48

Source: Computed from GDHS 2014 * per 1000 live births

Table 132: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorest – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.003	2013.1	0.001	0.005
20 – 24	2	0.059	2009.7	0.051	0.068
25 – 29	3	0.076	2008.2	0.060	0.082
30 – 34	5	0.118	2008.6	0.082	0.118
35 – 39	10	0.119	2009.9	0.077	0.110
40 – 44	15	0.127	2010.3	0.078	0.111
45 – 49	20	0.160	2007.4	0.089	0.129
Total*				73	103

Source: Computed from GDHS 2014 * per 1000 live births

Table 133: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorest – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.1	0.000	0.000
20 – 24	2	0.059	2009.8	0.050	0.069
25 – 29	3	0.077	2008.0	0.059	0.084
30 – 34	5	0.112	2008.0	0.075	0.112
35 – 39	10	0.104	2008.8	0.066	0.095
40 – 44	15	0.113	2008.9	0.068	0.099
45 – 49	20	0.122	2005.8	0.068	0.099
Total*				67	97

Source: Computed from GDHS 2014 * per 1000 live births

Table 134: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorest – Male)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.007	2013.0	0.007	0.008
20 – 24	2	0.059	2009.7	0.052	0.067
25 – 29	3	0.070	2008.4	0.057	0.075
30 – 34	5	0.124	2009.0	0.090	0.124
35 – 39	10	0.136	2010.7	0.090	0.125
40 – 44	15	0.137	2010.3	0.087	0.120
45 – 49	20	0.198	2008.6	0.112	0.161
Total*				79	108

Source: Computed from GDHS 2014 * per 1000 live births

Table 135: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorer – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.003	2013.1	0.004	0.004
20 – 24	2	0.059	2009.9	0.054	0.072
25 – 29	3	0.076	2008.4	0.054	0.072
30 – 34	5	0.118	2008.6	0.049	0.065
35 – 39	10	0.119	2009.7	0.061	0.084
40 – 44	15	0.127	2010.0	0.073	0.103
45 – 49	20	0.160	2007.1	0.081	0.117
Total*				55	75

source: Computed from GDHS 2014 * per 1000 live births

Table 136: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorer – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.009	2013.3	0.009	0.012
20 – 24	2	0.062	2009.8	0.052	0.072
25 – 29	3	0.058	2008.3	0.046	0.062
30 – 34	5	0.060	2008.5	0.045	0.060
35 – 39	10	0.083	2009.7	0.055	0.077
40 – 44	15	0.089	2010.4	0.060	0.079
45 – 49	20	0.157	2008.0	0.083	0.126
Total*				49	66

Source: Computed from GDHS 2014 * per 1000 live births

Table 137: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Poorer – Male)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.061	2009.7	0.053	0.069
25 – 29	3	0.079	2008.2	0.064	0.085
30 – 34	5	0.070	2008.7	0.054	0.070
35 – 39	10	0.100	2010.1	0.069	0.093
40 – 44	15	0.154	2010.6	0.096	0.134
45 – 49	20	0.178	2007.8	0.102	0.145
Total*				62	83

Source: Computed from GDHS 2014 * per 1000 live births

Table 138: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Middle – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.006	2013.1	0.006	0.007
20 – 24	2	0.026	2009.9	0.023	0.029
25 – 29	3	0.060	2008.5	0.048	0.064
30 – 34	5	0.064	2008.9	0.049	0.064
35 – 39	10	0.090	2010.4	0.061	0.083
40 – 44	15	0.097	2010.9	0.062	0.085
45 – 49	20	0.139	2008.1	0.079	0.113
Total*				54	71

Source: Computed from GDHS 2014 * per 1000 live births

Table 139: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Middle – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.010	2013.0	0.010	0.013
20 – 24	2	0.022	2009.9	0.020	0.025
25 – 29	3	0.063	2008.7	0.050	0.068
30 – 34	5	0.069	2009.5	0.051	0.069
35 – 39	10	0.074	2011.2	0.050	0.069
40 – 44	15	0.100	2012.0	0.062	0.088
45 – 49	20	0.114	2009.3	0.065	0.094
Total*				50	69

Source: Computed from GDHS 2014 * per 1000 live births

Table 140: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Middle – Male)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.012	2013.1	0.000	0.000
20 – 24	2	0.029	2009.8	0.026	0.014
25 – 29	3	0.054	2008.2	0.045	0.057
30 – 34	5	0.062	2008.4	0.048	0.062
35 – 39	10	0.106	2009.6	0.072	0.098
40 – 44	15	0.094	2010.0	0.063	0.083
45 – 49	20	0.176	2007.0	0.101	0.144
Total*				55	72

Source: Computed from GDHS 2014 * per 1000 live births

Table 141: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richer – Both Sexes)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.015	2013.2	0.015	0.018
20 – 24	2	0.044	2010.0	0.039	0.050
25 – 29	3	0.044	2008.0	0.037	0.047
30 – 34	5	0.068	2007.5	0.051	0.068
35 – 39	10	0.081	2007.8	0.056	0.075
40 – 44	15	0.073	2007.5	0.049	0.065
45 – 49	20	0.139	2004.2	0.079	0.113
Total*				48	63

Source: Computed from GDHS 2014 per 1000 live births

Table 142: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richer – Female)

Age group of mothers	Age X	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.0	0.000	0.000
20 – 24	2	0.027	2009.6	0.024	0.030
25 – 29	3	0.032	2008.1	0.027	0.034
30 – 34	5	0.063	2008.7	0.047	0.063
35 – 39	10	0.057	2010.3	0.040	0.053
40 – 44	15	0.088	2011.0	0.056	0.078
45 – 49	20	0.175	2008.1	0.090	0.140
Total*				38	50

Source: Computed from GDHS 2014 * per 1000 live births

Table 143: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richer – Male)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.054	2013.3	0.062	0.082
20 – 24	2	0.047	2010.4	0.046	0.058
25 – 29	3	0.049	2007.9	0.046	0.059
30 – 34	5	0.075	2006.2	0.055	0.072
35 – 39	10	0.101	2005.0	0.071	0.096
40 – 44	15	0.042	2003.6	0.045	0.057
45 – 49	20	0.148	1999.9	0.079	0.108
Total*				57	76

Source: Computed from GDHS 2014 * per 1000 live births

Table 144: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richest – Both Sexes)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.2	0.000	0.000
20 – 24	2	0.000	2009.9	0.000	0.000
25 – 29	3	0.056	2007.6	0.046	0.059
30 – 34	5	0.065	2006.6	0.050	0.066
35 – 39	10	0.074	2006.4	0.052	0.069
40 – 44	15	0.064	2005.7	0.044	0.057
45 – 49	20	0.237	2002.3	0.122	0.189
Total*				49	65

Source: Computed from GDHS 2014 * per 1000 live births

Table 145: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richest – Female)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.3	0.000	0.000
20 – 24	2	0.000	2010.5	0.000	0.000
25 – 29	3	0.057	2008.0	0.046	0.061
30 – 34	5	0.052	2006.2	0.040	0.052
35 – 39	10	0.083	2004.8	0.055	0.077
40 – 44	15	0.045	2003.2	0.032	0.041
45 – 49	20	0.097	1999.5	0.058	0.081
Total*				47	63

Source: Computed from GDHS 2014 * per 1000 live births

Table 146: Estimation of infant and under five mortality using Palloni – Heligman Variant of the Brass Method for 2014 GDHS (Richest – Male)

Age group of mothers	Age x	Probability of dying by age x	Reference date	Infant mortality rate	Probability of dying by age 5
15 – 19	1	0.000	2013.2	0.000	0.000
20 – 24	2	0.000	2009.7	0.000	0.000
25 – 29	3	0.060	2007.5	0.050	0.064
30 – 34	5	0.076	2006.8	0.058	0.076
35 – 39	10	0.059	2006.9	0.043	0.055
40 – 44	15	0.080	2006.5	0.055	0.071
45 – 49	20	0.454	2003.1	0.232	0.371
Total*				50	65

Source: Computed from GDHS 2014 * per 1000 live birth

APPENDIX C: TEST OF DIFFERENCES FOR INFANT MORTALITY

Table 147: Test of difference for Infant Mortality estimates

Background characteristics	Infant mortality (95% Confidence interval)		
	Direct Method	**Trussell Method**	**Palloni Heligman Method**
Region			
Western	40 (28, 51)	36 (29, 43)	43 (41, 45)
Central	48 (35, 61)	53 (48, 58)	58 (52, 64)
Greater Accra	37 (24, 49)	34 (32, 36)	35 (24, 46)
Volta	42 (27, 57)	43 (36, 50)	47 (38, 56)
Eastern	43 (29, 58)	45 (41, 49)	51 (46, 56)
Ashanti	63 (48, 79)	65 (62, 68)	67 (65, 69)
Brong Ahafo	38 (29, 47)	46 (31, 61)	49 (44, 54)
Northern	53 (39, 67)	75 (73, 77)	87 (84, 90)
Upper East	46 (30, 62)	55 (43, 67)	64 (62, 66)
Upper West	64 (47, 81)	69 (51, 87)	79 (71, 87)

Table continued

Place of residence			
Urban	49 (41, 58)	42 (41, 43)	50 (40, 60)
Rural	46 (40, 52)	55 (54, 56)	61 (57, 65)
Wealth status			
Poorest	55 (44, 65)	65 (60, 70)	73 (67, 79)
Poorer	44 (34, 55)	48 (42, 54)	55 (49, 61)
Middle	39 (29, 49)	48 (44, 52)	54 (51, 57)
Richer	47 (34, 60)	46 (41, 51)	48 (44, 52)
Richest	51(36, 67)	41 (35, 47)	49 (44, 54)
Level of education			
No education	53 (46, 60)	63 (56, 70)	73 (65, 81)
Primary	51 (41, 60)	52 (41, 63)	59 (45, 73)
Secondary	42 (36, 49)	42 (40, 44)	45 (43, 47)
Higher	45 (12, 77)	34 (32, 36)	35 (34, 36)

Source: Computed from GDHS 2014 per 1000 live birth

APPENDIX D: TEST OF DIFFERENCES FOR UNDER FIVE MORTALITY

Table 148:Test of difference for Under five Mortality estimates

Background characteristics	Under five mortality (95% Confidence interval)		
	Direct Method	Trussell Method	Palloni Heligman Method
Region			
Western	56 (40, 71)	50 (38, 62)	56 (53, 59)
Central	69 (52, 85)	79 (70, 88)	80 (73, 87)
Greater Accra	47 (35, 59)	43 (37, 49)	44 (28, 60)
Volta	61 (44, 79)	62 (50, 74)	63 (50, 76)
Eastern	68 (50, 86)	65 (57, 73)	69 (63, 75)
Ashanti	80 (61, 98)	88 (70, 106)	90 (88, 92)
Brong Ahafo	57 (44, 69)	62 (56, 68)	65 (58, 72)
Northern	111 (87, 134)	118 (115, 121)	127 (123, 131)
Upper East	72 (53, 91)	83 (81, 85)	89 (85, 93)
Upper West	92 (72, 111)	108 (85, 131)	114 (100, 128)

Table continued

Place of residence			
Urban	64 (55, 74)	61 (56, 66)	67 (60, 74)
Rural	75 (65, 84)	82 (75, 89)	84 (77, 91)
Wealth status			
Poorest	92 (78, 106)	101 (92, 110)	103 (93, 113)
Poorer	73 (62, 84)	74 (67, 81)	75 (66, 84)
Middle	61 (48, 73)	71(64, 78)	71 (65, 77)
Richer	55 (41, 69)	59 (56, 62)	63 (57, 69)
Richest	64 (47, 80)	60 (58, 62)	65 (62, 68)
Level of education			
No education	92 (83, 101)	96 (94, 98)	103 (89, 117)
Primary	72 (41, 60)	79 (62, 96)	80 (57, 103)
Secondary	55 (48, 61)	58 (45, 71)	59 (51, 67)
Higher	48 (15, 80)	47 (45, 49)	47 (44, 50)

Source: Computed from GDHS 2014 per 1000 live births