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EVALUATION AND ADJUSTMENT OF AGE SEX DATA OF THE POPULATION AND HOUSING CENSUS OF GHANA 2000 AND 2010

BY

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DECLARATION

I hereby declare that, except for references to other people's work, which have been duly acknowledged, this work is the result of my own study carried out in the Regional Institute for Population Studies under the supervision of Professor Samuel Kwesi Gaisie, and that neither part nor whole of this work has been presented anywhere for the award of any degree.

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Date

PROF. S.K. GAISIE

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Date

DEDICATION

This work is dedicated to my wife, Gloria;

My children, Seyram and Sedem,

And also to my mother and siblings.

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The Almighty God is glorified for making it possible for me to complete this work.

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TABLE OF CONTENTS

TITLE PAGE

TITLE PAGE

List of Tables

Page

List of Figures

APPENDICES

ABSTRACT

The simplest and most basic census item age, mostly present difficulties with regard to its accuracy in statistically underdeveloped countries where civil registration coverage is limited in terms of its accessibility. The study aimed at evaluating and adjusting age data of the population and housing census of Ghana. Several evaluation tools were used to examine the errors. These include visual inspection of the data and at the same time graphing the single age data which revealed heaping at certain digits especially 0 and 5. Comparison was also made using computed sex ratio for Ghana and some selected African countries. Though there was a decline in the sex ratio from 97.3 in the year 2000 to 95.2 in 2010, Ghana's sex ratio fell within the standard for an African country. The trend of decline experienced in the sex ratio at the national level, however affected most of the administrative regions of Ghana especially Ashanti, Greater Accra and Western regions. This phenomenon was attributed to the plausibility of more female migration to these regions.

Analysis based on age ratio showed that the ages of females in the 20 to 29 age groups had been exaggerated plausibly because of "assuming a typical marriage age". Likewise, ages of both males and females 50 years and above were misreported either by overstatement or understatement resulting in erratic fluctuations (signifying errors) when the ratios are plotted on a line graph. A relationship between literacy and digit preference was also established where it became evident that non-literate heads of household misreported more than their literate counterparts.

Detection of error in the data resulted in the need to adjust the age-sex data. The Strong Smoothing technique proved to be closer to the observed population data.

At the end, some recommendations were made to improve the collection of age sex data in future censuses and survey. Notable among them are for the Ghana Statistical Service to sensitize enumerators on potential age heaping issues. Also, the GSS should explore ways of introducing self administered questionnaire to household that have the head or other responsible member literate.

CHAPTER ONE

INTRODUCTION

1.1 Background

A Population and Housing census is "the total process of collecting, compiling, evaluating, analyzing, and publishing or otherwise disseminating demographic, economic, and social data pertaining at a specified time, to all persons and their living quarters in a country'' (UN, 2008). Population and housing censuses are a principal means of collecting basic population and housing statistics as part of an integrated programme of data collection and compilation aimed at providing a comprehensive source of statistical information for economic and social development planning, for administrative purposes, for assessing conditions in human settlements, for research, and for commercial and other activities. As a result, the facts essential to governmental policy making, planning, and administration are obtained from a census.

Post-independence Ghana had witnessed five census counts (1960, 1970, 1984, 2000, and 2010). But out of these, it is only the 2000 and 2010 censuses that the country combined both population and housing census as one activity.

A Population census is a complex, large-scale operation undertaken once in every ten years. Due to the complexities involve in its operation, a perfect census is unattainable. The data from censuses all over the world are prone to errors. The common errors are age misreporting and digit preference. These errors are more common in developing countries than in developed countries. It is therefore imperative to evaluate age-sex data from censuses before they are used.

1.2 STATEMENT OF THE PROBLEM

The basic inputs for national policy formulations and most of the demographic research studies are the data obtained from population censuses. Among the large volume of data gathered in a census, age and sex data play a vital role in population studies. The age-sex structure is one of the most fundamental characteristics of population composition. Past variations in the basic components of population change, i.e. Fertility; mortality and migration are reflected in the age-sex structure. Conversely, the age-sex composition of a population affects its fertility behaviour, mortality and morbidity levels, migratory movements, labour force participation and a host of other factors. Further, the age-sex data are the basic inputs for making population projections both at national and sub-national levels. Age-sex data are therefore almost always essential for analysis of population dynamics.

In spite of all the important place age-sex data occupy in the discipline of population studies, they are subject to various kinds of systematic errors making them inaccurate. The two major types of errors are coverage and content errors. Coverage errors result from the omission or duplication of individuals; hence it affects all the information collected including the age-sex data.

Content errors, on the other hand, occur due to inadequate information supplied or mistakes made in reporting or recording information. A common form of content error is the misreporting of age. Misreporting of sex is generally rare. But age misreporting/misstatement or digit preference seriously affects the quality of age data. The preference for certain digits, such as those ending in zero and five or even numbers certainly aggravates the problem of age data.

Age is defined as the interval of time between the date of birth and the date of the census. There are two common approaches in the collection of age data (The date of birth in terms of day, month and year; and completed age; that is age at the person's last birthday).

The date of birth approach gives more precise information and is used whenever most people know their birth dates. The Second approach is likely to provide less accurate information and leads to age misreporting particularly for children under one year of age and rounding the nearest age ending with zero or five.

Though the data collection method in Ghana's 2010 Population and Housing census attempted to combine the two approaches to collect age data, using the head of household or any other member as a proxy to collect this information as the case has always been, results in a higher probability of age misstatement/misreporting.

Since age-sex data form the backbone of demographic data, the recommendations of the International Conference on Population and Development (1994) to integrate population variables into development planning can only be meaningful if there is accurate and reliable data on age and sex. The essence of evaluation therefore is to identify these errors by use of some demographic methods and models and adjust the data accordingly. The questions this work is seeking answers to are:

1) Has age misreporting minimized in the 2010 census if compared to the 2000 Census?

2) Is there a relationship between literate heads of household and non-literate heads in terms of misreporting?

3) Is there a rank order in digit Preference in the 2010 population census of Ghana?

1.3: RATIONALE OF THE STUDY

The personal characteristics of age and sex hold positions of prime importance in demographic studies. Age structure is a crucial component in health and demographic analysis as it provides a quick and ready tool for mapping the broad contours of demographic history and make up of a population. Similarly, the future demographic events are influenced to a large extent by the present sex-age structure, other things being equal. In our part of the world, the importance of census data on age in studies of population growth is even greater when adequate vital statistics from a registration system are not available (United Nations, 1964). Though conceptually the collection of information about age seems to be a simple and straightforward task, the facts are that age returns in censuses the world over and especially from developing countries were found to be far from the true ages for a large part of the population. Apart from differential under-enumeration in various ages, the age data suffer from distortion owing to preferences for certain ages and digits.

The organization which is charged with compiling and disseminating a body of data is naturally responsible for informing users about the accuracy and limitations of the data, as well as for preparing "adjusted" data if necessary. This is because the lay consumers of data do not take into consideration how reliable and accurate the data are and even if they do, lack the necessary skills and tools to evaluate and adjust such data.

The study therefore is undertaken in an attempt to assess the reliability and coverage of population data in the 2010 census of Ghana and show how age reporting and enumeration biases affected the results that could be misleading for development planning and policy making purposes.

1.4 OBJECTIVES OF THE STUDY

The main objective of the study is to evaluate and adjust the age and sex data of the 2010 Population and Housing Census of Ghana making it more reliable to be used by the various stakeholders such as researchers, planners, and policy makers.

The specific objectives of the study are:

i) To study the nature of errors in the age-sex data.

ii) To study sex differential in age misreporting.

iii) To study the rural-urban pattern of age misreporting.

iv)To examine the relationship between literacy and digit preference.

v) To generate a characteristic digit preference for Ghana's 2010 population age sex data.

vi) To see in totality, whether there is an improvement in the age-sex data of 2010 census as compared to the 2000 census.

CHAPTER TWO

LITERATURE REVIEW

2.1 IMPORTANCE OF AGE DATA:

In all demographic inquiries, data on age is one of the most important items that are collected. This is because the age and sex structure of a population provides basic information necessary for planning and for providing key insights on social and economic characteristics. Age composition helps identify populations for schooling, employment, voting, and retirement. Sex distribution is important for identifying social characteristics, trends in community structure, and the population's economic potential.

2.2 THE PROBLEM OF PROXY REPORTING.

In a household interview, there is frequently one respondent who supplies the majority of the information. In societies in which one's own age is not important, the ages of others may seem even less important. Van de Walle (1968) has indicated that all African demographic survey/censuses share the problem of trying to record the ages of people who do not know their exact ages. Most problems of age misreporting begin with the interviewee's ignorance of exact numbers. This takes two forms: ignorance of one's own age and ignorance about the ages of others about whom questions are asked. This phenomenon results in distortions in the age data. The distortion ranges from omissions due to understatement of certain ages to heaping on other terminal digits. Reasons given for the occurrence of these in developing countries include high illiteracy rates, ignorance of age in the sense of the completed number of years, deliberate misstatement, and inability to understand the question asked (Kpedekpo, 1982; Newell, 1988).

Shryrock et al. (1973) indicate that studies on age reporting error need special attention since the errors in the age distribution, particularly in the censuses are examined more intensively than any other information.

Most researchers agree that the age data compiled by national population censuses may have some irregularities in age reporting. These errors are quite common in many developing countries as compared to developed countries. Irregularities that refer to digit preference and digit avoidance will normally distort the age distribution of the population. In the absence of irregularities in age reporting, the count of adjacent ages should be virtually smooth.

In studies conducted in Africa, Asia and Latin America, Coale and Demeny (1967) found two typical patterns of age misreporting in these populations, namely, the "African –South Asian pattern" which showed more distortions in male than in female populations, whilst in Latin American populations the converse is true.

Mason and Cope (1987) identified four sources that could be attributed to age misreporting in any censuses or surveys. These are ignorance of the actual ages among respondents; miscommunication between interviewers and informants; the distortion of age to meet preconceptions or social norms about the relationship of age to other social characteristics or events; and finally errors in recording or processing.

Ueda (1980), stated that one of the major types of errors most commonly found in the sex, age data derived from censuses or similar surveys is the false reporting of age. In many cases, the erroneous reporting of age is attributable to the ignorance of respondent. In most cases, ages are being reported on some particular digits, "0" and "5".

Mukherjee and Mukhopadhyay (1988) in their study using Turkish Census data found that age heaping occurs in terminal digit “0” and “5”. Kabir and Chowdhury (1981) in their analysis of census data of Bangladesh found errors in age reporting due to digit preference and there were strong tendency to report ages ending with “0” and “5”, with subsidiary heaping at ages ending with “8” and “2” respectively.

2.3 OLD AGE AND AGE MISSTATEMENT:

Some researchers found that higher tendency of age heaping occurs in the older age category of the population. Hill, Preston et. al. (1997) noted that the age misreporting remains substantially high for older African American. Nagi, Stockwell and Snavley; (1973) revealed that age heaping is a major source of inaccuracy in the age statistics in many of the developing nations on the African continent, particularly among Islamic populations. This phenomenon was found to be more pronounced among women than men, and it tends to increase with age..

Aimee and Samuel (1991) concluded that misreporting is most severe at an older age. They found evidence of very pervasive overstatement of age at advanced ages. The evidence of increasing age misstatement with old age is consistent with the observation that literacy rates have also declined with age, since age misstatement is associated with literacy and low educational attainment.

Similar findings have been documented in studies across the African continent. These were exemplified by Hadgu, (1973), Palay (1973), Sheku (1974) and Rafiq (1983). Hadgu in an attempt to evaluate the age-sex data of the 1967 census of Tanzania observed the concentration at certain terminal digits for both rural and urban by sex, mainly at 0 and 5 terminal digits beyond age 5. This was also confirmed by Palay in his "Evaluation of 1962 population data of Liberia". The 1966 census of Lesotho examined by Sheku also revealed a significant heaping at digits ending in 0 and 5 and at digits ending in even numbers especially 2 and 8 at the middle and higher ages. He mentioned errors of misstatement, heaping at particular ages, avoidance of digits ending with odd numbers, and the influence of age-sex selective emigration as probable causes for the irregular and unbalanced shape of the pyramids of the that country. In Uganda, the situation was not different when Okoye in his study concluded that the single year data exhibited considerable heaping at ages 0 and 5 but for both sexes heaping was more pronounced at digits ending in 0 than those ending in 5.

2.4 UNDER ENUMERATION IN EARLY YEARS OF AGE:

Bairagi and Aziz, et.al.(1982) pointed out that misreporting also occurs in the early age of the population especially in the rural area. The misstatement for young children in rural Bangladesh increase monotonically with age and systematic errors in age misstatement displays modest overstatement for the first years of life and more pronounced understatement for ages 4, 5 and 6 the population censuses taken in Ghana had also undergone similar evaluation exercises. These can be seen in the works of Ameka, (1987); Togoh, (2003). Evaluating the age-sex data of the 1984 census of Ghana, Emeka found out the small number of children reported in age group 0-4 for both males and females. A feature she saw to be unusual about the age structure of the population. She, however attributed this either to the under enumeration of the age group or a decline in fertility which was reported to have set in at the time. However, the suggested under-enumeration was plausible to her since fertility during the time was high. In a similar study on Ghana's 2000 population census, Togoh also found similar under enumeration of the 0-4 age group and preference for digits ending in 0 and 5 do exist but improved as compared to the preference in the 1984 census data. Also in the Population Data Analysis Report of the 2000 census of Ghana, there was suspicion of massive underreporting of infants and young children in the two upper regions of Ghana indicating that age misreporting have distorted the data (Gaisie, 2005). Gaisie indicated that differential age misstatements by sex tend to complicate the assessment of the age sex balance within individual age groups.

2.5 THE INFLUENCE OF TRADITION AND BELIEFS:

Tradition and beliefs also have influence on age misstatement in some parts of the world. In the method of age- reckoning for traditional Chinese or Muslim community, Seng (1959), Hock (1967) pointed out that the Chinese traditional method of age-reckoning differs from the international method in a systematic manner. On the day a child is born, he or she is already considered as one year old. If a child was born one week before Chinese New Year, after two weeks the child will be two years old. In some Asian countries such as Korea and China, there is sometimes preference for age ending in “3” because the numeral “3” sounds like the word or character for life. However, they would avoid the number “4” because it has the same sound as the word or character meaning death. Age at first marriage, especially in the developing countries also contributes to age misreporting. In some developing countries marriage at very young ages still exist. Indonesia is one example of a country characterized by relatively young age at marriage for females (Savitridina, 1997). Interviewers have some motivation to shift the ages of women who are within the boundaries of the 15 to 59 interval to be below or above the minimum age of respondent eligibility. There may also be some shifting of birth to be outside the maximum age of eligibility for the health questions (Pullum, 2005).

2.6 DATA PROCESSING ERRORS:

Once the data have been collected, they must be processed before analysis can begin. At this stage there are several ways in which errors can be made. First, errors can occur any time the data are transferred from one form to another, for example, during coding or keypunching.

In the 1960 U.S. census about 10 percent of the undercount and 40 percent of the over count were caused by data processing errors (Steinberg, 1966). Second, errors arise when missing values are replaced by statistical procedures, as in the attribution of characteristics, or when data-cleaning procedures reject individuals whose characteristics are in fact very different from the norm. A third source of error is the loss of data or the specious inflation of data through double counting of questionnaires, which is not apt to affect the age distribution because the errors introduced are random. Finally, errors can arise during the tabulation of the results.

Although all four of these problems occur in almost every survey, there is little documentation of them. Two studies of data processing errors in the U.S. censuses of 1950 (Coale and Stephan, 1962) and 1960 (Akers and Larmon, 1967) have demonstrated how processing errors can distort the analysis even when those errors are very rare. Rare processing errors are most important when they change the reported characteristics of an individual so that he or she moves from a very large category to a small category. For example, in the 1950 U.S. census a slight error in keypunching could turn a white child of the head of the household into a male Indian.

All these attest to the fact that there are inherent errors in demographic data which are introduced during data collection and processing.

CHAPTER THREE

METHODOLOGY

3.1: Sources of data, Scope and Limitations:

To measure the quality of age-sex data of Ghana's 2010 population and housing census, several analytical tools have been used to determine the nature and extent of errors inherent in the data. These include visual inspection/ Graphical method, mathematical methods, and demographic techniques.

The main source of data for the study was the 2010 Population and housing census of Ghana. Apart from the data in the summary report of final results, single age data which was used in most cases were generated from the Census Secretariat (see appendix A). These include single age data for the total population by sex, locality and for household heads (with emphasis on literacy). Other sources were the 2000 Census reports and the United Nations Demographic yearbook (UN, 2011, pp. 158-174).

There were 10 administrative regions in Ghana during the 2010 Population and Housing Census as they were in 1984 and 2000. In terms of districts, however, coverage was different from one census to the other. There were 110 and 65 districts that were covered in 2000 and 1984 respectively. In 2010, the census was conducted in 170 administrative districts (made-up of 164 districts/municipal and 6 metropolitan areas). The six metropolitan areas in all have 33 sub-metropolitan assemblies which the statistical service considered as districts for the purpose of the census (GSS, 2012).

These developments do not allow comparisons to be made on district bases, hence put a limitation on the study.

3.2: Visual Inspection/ Graphical Method.

Single year age-sex data at national level will be examined first by visual inspection. This will be done to observe whether there are unusual concentrations at particular ages ending in different digits. Examples are females whose ages were 30 years with reference to the census night were 317,248; those 29 years were 148,665, and those 31 years were 139,455. Also, males aged 45 years were 159,271 whilst 79,428 and 80548 preceded and succeeded respectively. If there exists evidence of observed unusual concentrations at some digits, it will be an indication of probable errors in the data. The single age data will then be graphed in a line form to see whether very erratic fluctuations will be depicted by peaks and troughs. The absence of a smooth descending curve with high ages in the graph could mean there are probable errors in the data. Further, inaccuracies detected will then be quantified by means of mathematical methods.

3.3. Sex Ratio.

The accuracy of the data will be examined by the patterns in sex ratio. This is because the sex ratio is independent of the absolute numbers of males and females. The sex ratio of a population is the number of males per 100 females (in each age group).

The approach to the evaluation of the quality of data on the sexes for Ghana will involve of observing the deviation of the sex ratio for the country as a whole from 100 which is the point of equality for the sexes. In the absence of migration, the sex ratio is expected to fall near 100.

A more careful evaluation of the data on the sex composition in Ghana will involve a check of the consistency of the sex ratio shown by the 2010 census with the sex ratio shown by the 2000 census for the 10 administrative regions of Ghana.

Computations will be done for some selected African countries including Ghana, to see whether the sex ratio for Ghana from the year 2000 to 2010 is within the accepted rate for an African country. With interest in age shifting/heaping or omissions, the age specific sex ratio will also be calculated for five-year age groups and subsequently the result will be plotted on a graph. Errors in the data which were the result of misreporting will then be detected again by erratic fluctuations on the graphs.

3.4 Age Ratios

Another method of evaluation that will be used to gauge the quality of age data is through the calculation of age ratios. Age ratio is usually defined as the ratio of the population in a given age group to one half of the population in the two adjacent age groups**.** Mathematically, it is computed as follows:

$$_5ARx = \frac{(_5Px)}{½(_5Px_{-5} + _5Px_{+5})} x100$$

Where:

5ARx = the age ratio for the age group x to x+4

5Px = the enumerated population in the age category x to x+4.

5Px-5 = the enumerated population in the adjacent lower age category.

5Px+5 =the enumerated population in the adjacent higher age category.

The computed age ratios will then be compared with the expected, which is usually 100. The discrepancy at each age group is a measure of net age misreporting.

3.5. Age-Sex Accuracy Index.

This technique proposed by the UN employs the age ratios and the sex ratio. It is defined symbolically as $3 * SRS + (ARS_{(m)} + ARS_{(f)})$. Where ($ARS_{(m)}$ and $ARS_{(f)}$) are respectively the Age Ratio Score for males and females; and SRS is the Sex Ratio Score. The computation is done for five year group ages.

3.6. Techniques to Measure Age Heaping

It is difficult to measure digit preference in the age distribution, because a precise distinction cannot be made between errors due to digit preference, other errors and real fluctuations in birth cohort size. However, indices have been developed to capture deviations from assumed rectangular distributions. Software programs such as the SINGAGE developed by the Population Division's International Programs Center (IPC), perform this type of analysis (Arriaga, 1994).In the indices, the population aged 23 to 62 is in scope. This age interval excludes the youngest and the oldest population groups where errors other than digit preference are prevalent. The program allows the calculation of three indices: Whipple, Myers and Bachi indices.

3.6.1: Whipple's Index

Whipple's Index, evaluates data with regard to age heaping on multiples of five (ie terminal digits 0 and 5) in the range 23 to 62. It is based on the following assumptions;

a) That errors from age reporting is heaviest on digits 0 and or 5.

b) The ages of childhood and old age (below 23 and above 62 respectively) are often more strongly affected by other types of errors of reporting rather than by preference for specific terminal digits.

Based on these assumptions, the ages of childhood and adults (below 23 and above 62) will be excluded in the computation of the Whipple's index. These, however, place limitations on the method as the data cannot be evaluated outside this age range. Also age preference for any of the other eight digits apart from 0 and 5 cannot be evaluated. The scale for its measure is from 100-500. Highly accurate data on the scale is less than or equal to 105; fairly accurate data ranges from 105-109.9; data that is approximate ranges from 110-124.9; Rough data ranges from 125-174.9 and a very rough data is greater than 175 on the scale.

It is measured as: $$\left[\frac{\sum(P^{25}+P^{30}+P^{35}+P^{40}\ldots P^{55}+P^{60})}{⅕\sum(P^{23}+P^{24}+P^{25}+P^{26}\ldots P^{61}+P^{62})}\right]\times 100$$

$$=\left[\frac{\sum_{23}^{62} p_a}{1/5\sum_{23}^{62} p_a}\right]\times 100 \qquad \text{(a ending in 0 or 5)}$$

On the other hand, heaping on terminal digits "0" is measured as:

$$\left[\frac{p_{30}+p_{40}+p_{50}+p_{60}}{1/10\sum(p_{23}+p_{24}\cdots p_{60}+p_{61}+p_{62})}\right]\times 100$$

The choice of the range 23 to 62 is standard, but largely arbitrary. In computing indexes of heaping, ages during childhood and old age are often excluded because they are more strongly affected by other types of errors of reporting than by the preference for specific terminal digits.

3.6.2. Myer's Index

Unlike the Whipple's index, the Myer's index reflects preferences (or dislikes) for each of the 10 terminal digits from "0" to "9". The method derives a blended population, which is essentially a weighted sum of the number of persons reporting ages ending in each of the ten terminal digits- 0 to 9. The method involves the determination of the proportion that the population ending in a given digit is of the total population 10 times, by varying a particular starting age for any 10 year age group.

The assumption underlying the method is that if there are no systematic irregularities in the reporting of age, the blended sum at each terminal digit should be approximately equal to 10 per cent of the total blended population. Should the sum at any given digit exceed 10 percent of the total blended population, is an indication of over selection of ages ending in that digit (digit preference). A negative deviation (or sum that is less than 10 percent of the blended total) indicates digit avoidance.

Data requirement and computation procedure:

- Requires single age data in its computation (Appendix A).
- The calculation of the index covers the range of age data beginning from 10 to an age ending on digit 9 (e.g., 10-69, 10-79, 10-89, etc);
- The process of computation breaks the data into two with the first part beginning at age 10 and the second at age 20.
- Corresponding weights are applied to eliminate imbalances.

- MI is expressed as: MI = ∑|MI-10|.

An example of the procedure is presented in Table 3.1.

Table 3.1. Methodological approach to Myer's and Bachi indexes

Digit (i) Col 1	Sum of Digit for age range 10-89 $A_{(i)}$ Col 2	Weight Col 3	Product Col. 4 (Col 2*Col 3)	Sum of Digit for age range 20-89 $B_{(i)}$ Col 5	Weight Col 6	Product Col 7 (Col 5*Col 6)	Blended Popn. Col 8 (Col 4+Col 7)	% of Blended Popn. $MI_{(i)}$ Col 9	Deviation from 10 $MI_{(i)}$ - 10 Col 10
0	A_0	1	A	B_0	9	$9B_0$	$A_0 + 9B_0$	$MI_{(0)}$	$MI_{(0)}-10$
1	A_1	2	$2A_1$	B_1	8	$8B_1$	$2A_1 + 8B_1$	$MI_{(1)}$	$MI_{(1)}-10$
2	A_2	3	$3A_2$	B_2	7	$7B_2$	$3A_2 + 7B_2$	$MI_{(2)}$	$MI_{(2)}-10$
3	A_3	4	$4A_3$	B_3	6	$6B_3$	$4A_3 + 6B_3$	$MI_{(3)}$	$MI_{(3)}-10$
4	A_4	5	$5A_4$	B_4	5	$5B_4$	$5A_4 + 5B_4$	$MI_{(4)}$	$MI_{(4)}-10$
5	A_5	6	$6A_5$	B_5	4	$4B_5$	$6A_5 + 4B_5$	$MI_{(5)}$	$MI_{(5)}-10$
6	A_6	7	$7A_6$	B_6	3	$3B_6$	$7A_6 + 3B_6$	$MI_{(6)}$	$MI_{(6)}-10$
7	A_7	8	$8A_7$	B_7	2	$2B_7$	$8A_7 + 2B_7$	$MI_{(7)}$	$MI_{(7)}-10$
8	A_8	9	$9A_8$	B_8	1	B_8	$9A_8 + B_8$	$MI_{(8)}$	$MI_{(8)}-10$
9	A_9	10	$10A_9$	B_9	0	0	$10A_9$	$MI_{(9)}$	$MI_{(9)}-10$
Total	$\sum A_{(i)}$	-		$\sum B_{(i)}$	-		Grand Blended Popn.	100.0	∑|MI-10|

The index of preference is the measure of the extent to which there is digit preference and/or avoidance. This is obtained as the absolute sum of deviation for each of the 10 terminal digits.

3.6.3. Bachi Index:

Despite their demonstrated practical usefulness, both Myer's and Whipple's indices have some minor theoretical defects: it is not possible to formulate the precise theoretical conditions under which Whipple's index would be exactly 100 and Myer's index exactly zero. Myer's for instance is faulted for double counting of errors. An ingenious method, developed by Bachi, avoids this defect. This is because the computation of Bachi index is somewhat more laborious than Myer's method, (U.N, 1955). It is derived from the Myer's Index and describes the sum of all the positive deviations from 10 unlike the Myer's Index which combines the two. It measures the proportion of people who instead of reporting their ages on certain digits preferred other digits.

It is computed as: $\frac{1}{2}\sum |MI-10.$

3.7. Intercensal Growth Rate

This method involves computing the growth rates using the 5 year age group data for two or more censuses using the exponential growth law which views change as occurring continuously rather than at discrete intervals. The growth rates for the specific age groups are expected to be close to the total growth rate. Any deviation from the overall growth rate suggests errors due to possibility of neither net over or under enumeration.

3.8: Cohort Survival Ratio

The data requirement for this method is census data for two successive censuses, grouped in 5 year interval. The procedure adopted here is to identify in the 2010 census data the survivors who were enumerated in the 2000 census as well. The assumption underlying this is that there is no migration during the intercensal period, and that the reduction in cohort numbers is due to mortality. Since it was a decennial period, the survivors to the age cohort 0-4, 5-9,…..65+, in 2000 should correspond to 10-14 ,15-19 ,…..75+; in the 2010 census. The ratio will be calculated by dividing the number of survivors at the current census (2010) by the corresponding number enumerated in the previous census (2000). The derived ratios are expected to decrease as age increases since the risk of dying is higher with the advancement in age. Any observed fluctuations in the pattern of survival ratios are associated with migration, age shifting, and net under/over enumerations.

3.9: THE USE OF SOFTWARE

Population Analysis System (PAS) consists of 45 spreadsheets for population analysis. Out of these, there are 11 that are used for the analysis of the Age Structure. The following will however be used in this work for analysis.

**ADJAGE Adjusts any population total by sex to a given age structure.

**AGESEX analyzes the age reporting in a population age and sex distribution. Calculates age and sex ratio indices and the United Nations age/sex accuracy index.

**AGESMTH smooths a population age distribution using several methods.

**PYRAMID makes an age pyramid by sex, with absolute numbers and percentages of the population data.

**SINGAGE Calculates the Whipple, Myers, and Bachi indices of age heaping based on enumerated population by single years of age.

3.10: Organization of the Study

This study has six chapters. Chapter one comprises of the introduction, statement of the problem, rationale of the study and the study Objectives. Chapter two has the literature review. The Sources, scope and limitation of the data, methodology and the organization of the study are in chapter three. Chapter four looks at data evaluation, while chapter five and six are respectively on data Adjustment and summaries of the major findings and recommendations for future data collection exercises.

CHAPTER FOUR

EVALUATION OF AGE AND SEX DATA

4.1 Introduction

Age is the most demographic variable in demographic analyses. It is affected by and a determinant of social, economic and demographic variables. On one hand, age is indicative of entry into education, the labour force and marriage; On the other hand, it is impacted by the component of population change, namely fertility, mortality and migration. As a result of these relationships, age forms the basis of classification for most demographic variables hence a more accurate knowledge of the age of a population is essential for successful social and economic planning. Based on this, the United Nation (1980) underlines the importance of age by recommending that developing countries should include a question on age in their censuses and demographic surveys. Shyrock and Siegel (1973) also argued that no census is worth the name if it excludes a question on age. Ghana in an attempt to achieve more accurate data on age asked questions on 1) the complete age of respondents and household members and, 2) the respondents' dates of birth including the month and the year. Low level of literacy usually points to a more inaccurate reporting of age in developing countries.

The end result of this is the heaping of the population on ages ending with some special digits especially '0' and '5'.

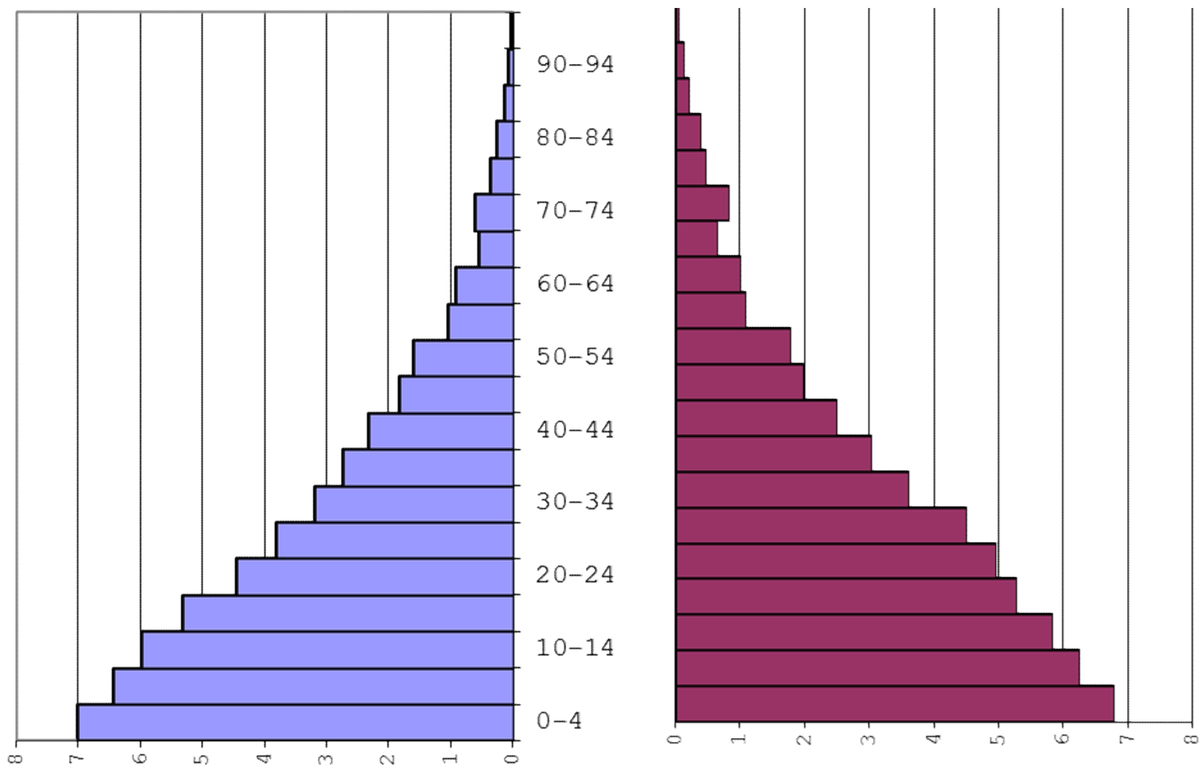
Having been informed with these problems, Spiegelman (1968:6) contended that one of the fundamental precautions that must be taken before embarking on the analysis and interpretations of demographic data is that "the quality of the observed data should be ascertained…."

4.2. THE AGE-SEX STRUCTURE OF GHANA'S POPULATION

The distribution of Ghana's population (Fig. 4.1) by sex indicates that out of a total of 24,658,823 people recorded as at 26th September 2010, there were 12,024,845 males and 12,633,978 females. This gives a sex ratio (number of males per 100 females) of 95.2 compared to 97.9 in 2000.

The population of Ghana can be described to have a youthful structure with a broad base that signify large numbers of children with an apex that narrows towards the end indicating a small number of the aged. The proportion aged less than 15 years declined from 41.3 percent in 2000 to 38.3 percent in 2010. The proportion of the population 65 years and older have also declined slightly from 5.3 percent in 2000 to 4.7 in 2010 (GSS, 2012). The population 15 years and above, however, had recorded an increase from 53.4 percent in 2000 to 61.7 within the ten year period. The age structure of the country's population, according to experts is basically shaped by the effects of high fertility and decreasing mortality rate.

Fig 4.1 Population Pyramid Of Ghana-2010



4.3 SEX RATIO

Data classified by sex can be used as an analytical tool. The sex ratio, which is expressed as the number of males per hundred females is used to compare the balance between the two sexes in different population groups irrespective of size, location, place and time. The sex ratio of a population is not expected to fluctuate from one period to another unless there have been major changes in the dynamics of population growth. A high or low sex ratio indicates a numerical dominance or deficiency of males. This could be brought about by a high/low sex ratio at birth, net migration, and the effect of mortality on the sexes. Sex ratio at birth is usually around 104 because of the biological fact that male births generally exceed female births. It then declined gradually with age due to lower mortality of females. The point of equality of the sexes is 100 hence the sex ratio of a population will fall close to 100. Also, errors in data originating from differential coverage of either sex may make the sex ratio high or low. Generally, the national sex ratio of countries ranges from 94 to 102 males per 100 females.

The national/general sex ratio of Ghana as at 26 September 2010 was 95.2 males per 100 females.

From Table 4.1 one can attest to the fact that the sex ratio for Ghana though within the generally accepted range for African countries, had reduced by 2.7 per cent within the decennial period from 97.9 to 95.2. This signifies the reduction in the male population over the period. There is therefore the plausibility of under enumeration in favour of the females.

Generally, the General sex ratios for the selected countries seem to fall below 100 except Algeria which exceeded the balance, hence male dominance of 102.6 per 100 females in 2008. This situation could explain how mobile the populace of the country is in terms of migration.

Assuming there are no coverage errors, then the reasons for the low sex ratios for the selected countries could be explained either by low sex ratio at birth or sex differential in mortality in favour of females.

Table 4.1: Sex Ratio for Ghana and some selected African countries for Specific years.

Country	Year	Sex Ratio (Males per 100(females)
Algeria	2008	102.6
Cameroun	2005	97.3
Ghana***	2000	97.9
Ghana***	2010	95.2
Kenya	2006	98.2
Mozambique	2007	93.5
Namibia	2004	94.7
Senegal	2008	96.9
Uganda	2006	94.0
Zimbabwe	2007	94.0

Source: Computed from United Nations, Demographic Year Book: 2009-2010.

**** Computed from the Census data of Ghana.*

Comparing the 2000 and 2010 sex ratios for the ten administrative regions of Ghana as shown in Table 4.2. One can observe that there is a general decline in the sex ratios except the Upper East and Upper West regions whose ratios increased marginally from 92.6 to 93.8; and 92.1 to 94.5 respectively. The trend observed in the two regions could plausibly be due to a reduction in continuous migration of females from the regions to Accra and Kumasi over the period where they render services as head porters. Also the census period fell within the raining seasons in the Northern part of Ghana hence, the likelihood of seasonal migrants from neighbouring Burkina Faso to these regions to work on the farms as well as coming as pastoralist.

Table 4.2: Sex Ratios by Administrative Regions, Ghana 2000 and 2010.

REGIONS	**SEX RATIOS**		**CHANGE IN SEX RATIO (2000-2010)**
	YEAR		
	2000	2010	
Western	103.2	100	- 3.2
Central	91.2	91.2	0
Greater Accra	97.7	93.6	- 4.1
Volta	93.6	92.8	- 0.8
Eastern	96.8	96.1	- 0.7
Ashanti	101.3	94.0	- 7.3
Brong Ahafo	100.3	98.2	- 2.1
Northern	99.3	98.4	- 0.9
Upper East	92.6	93.8	1.2
Upper West	92.1	94.5	2.4

Source*: Computed from the 2000 and 2010 censuses of Ghana.*

In Table 4.2, the situation in six out of the ten administrative regions is not quite different from what was observed for the country as a whole as they also recorded a similar decline. One significant thing about the decline experienced in the sex ratio for Western Region from 103.2 in 2000 to 100.0 in 2010 is that the male dominance in the region has now maintained a balance over the ten year period. This is contrary to the expectation that because of the oil find, more males would have migrated to the region since migration is sex selective. It could plausibly be that the region has received female migrants from other parts of the country or neighboring La Cote d'Ivoire where Ghanaian women normally migrate to for some commercial activities. The political upheaval in the La Cote d' Ivoire which led to the postponement of their presidential elections, several times in 2009 could have made these women return home to beef up the female population in the region. Ashanti which also had more males than females during the 2000 census, resulting in a higher sex ratio than the general rate for the country, had lost its male population by 7.2 percent over the ten year period and now recorded a sex ratio of 94.0 that fell below the general sex ratio for the country. This huge loss might be probably due to the region receiving more female porters from the two Upper regions.

The situation in Greater Accra is also quite interesting. Though the region also recorded a lower sex ratio than the national average in the 2000 census, the magnitude of the loss recorded in terms of the male population as compared to the female population in the region within the decennial period is 4.1 per cent. This means that the region is continuously maintaining its female dominance. This confirms the probable continuous migration of females to the region where they engage in sales and other service activities.

Table 4.3 shows the age specific sex ratio by five year age groups computed from 2000 and 2010 population census data of Ghana.

Table 4.3 Age Specific Sex Ratio of Ghana 2000 and 2010.

AGE GROUP	SEX RATIO 2000	Successive Difference	Sex Ratio 2010	Successive Difference
0-4	99.3	X	103.5	X
5-9	100.4	+1.1	103.3	- 0.2
10-14	103.6	+3.2	102.7	- 0.6
15-19	104.2	+0.6	100.9	- 1.8
20-24	91.1	-13.1	90.0	-10.9
25-29	87.8	- 3.3	85.2	- 4.8
30-34	88.5	+0.7	88.9	+3.7
35-39	91.1	+2.6	90.9	+1.9
40-44	99.9	+8.8	93.3	+2.4
45-49	110.0	+10.1	93.4	+0.1
50-54	97.1	-12.9	90.0	- 3.4
55-59	105.7	+8.6	97.5	7.5
60-64	93.8	-11.9	91.3	- 6.3
65-69	99.6	+5.8	86.4	- 4.8
70-74	89.8	- 9.8	74.1	-12.4
75+	103.9	-	68.4	-
Absolute Deviation		**92.5**		**60.8**
Mean Sex Ratio Score		**6.6**		**4.3**

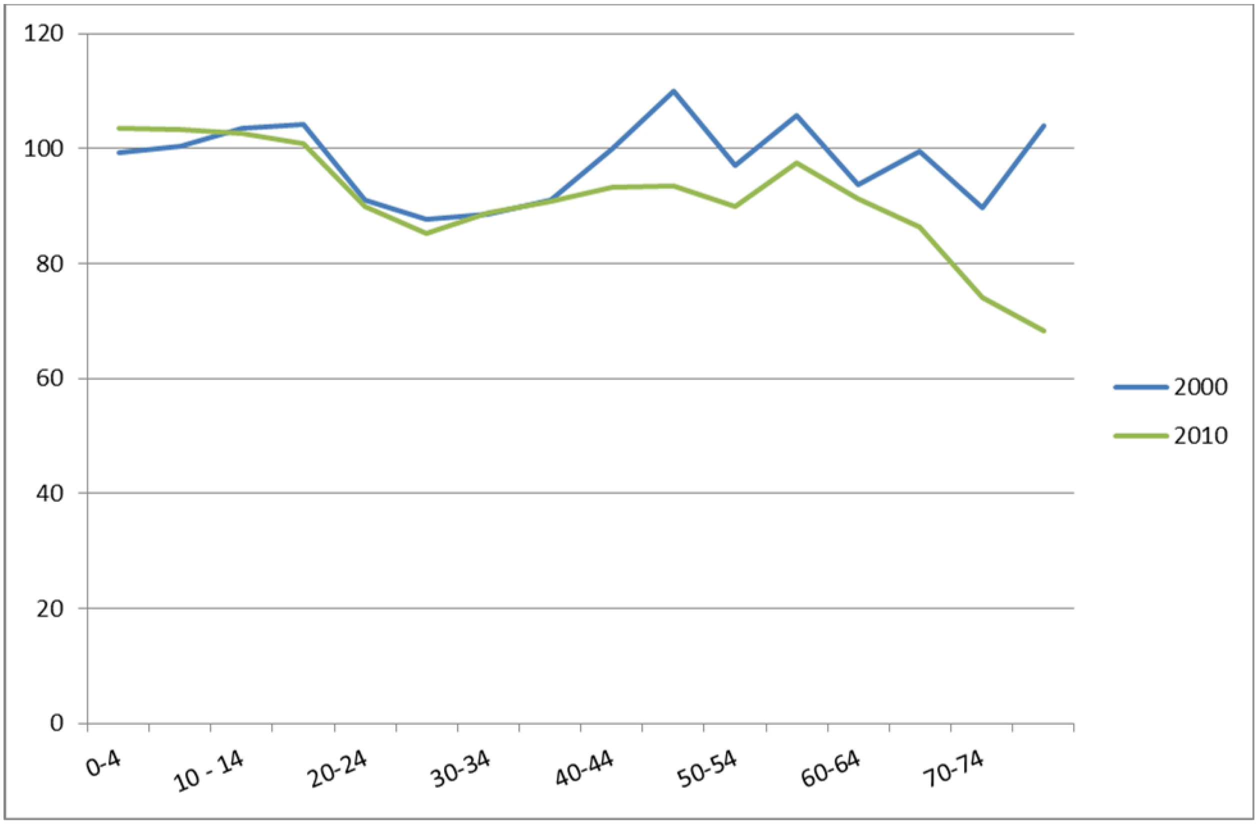
A careful examination of the 2010 census clearly indicates that the sex ratio of 103.5 for 0-4 age group is a desired number of males per 100 females in a young age group. This is because the sex ratio at birth is expected to range from102 to105. Generally, the pattern of sex ratio observed should have shown a smooth pattern of gradual decline in sex ratio with age. The patterns in the two censuses, however, showed the pervasiveness of irregularities due to the misstatement of age, which was very widespread in the 2000 census than the 2010 census. One could have expected a higher sex ratio from 20-49 years due to the high rate of maternal mortality in Ghana. The distortions observed here can be attributed to;

a) Fluctuations in demographic components such as mortality and migration.
b) Fluctuations in sex ratio at birth.
c) Misreporting of ages and/or differential completeness of enumeration of males and females in different ages.

More so, an unprecedented surge in the sex ratio for age groups 45-49 and 55-59 could have been due to over statement of the males and understatement of the females since the general expectation is for the sex ratio to reduce with increasing ages.

The sex ratio score for 2010 was 4.3 and this is 2.3 per cent lower than the score of 6.6 for 2000. This indicates a reduction in error in the 2010 census data when compared with the 2000 data.

Fig. 4.2. Sex Ratio by Age-Ghana 2000 and 2010.



The curve in Fig.4.2 Is expected to show how 2010 sex ratio is close to the expected pattern of smooth declining trends. But age group 55-59 seems to be an outlier. Comparison of five year sex ratios with 2000 census immediately reveals that the erratic fluctuations that prevailed in 2000 had minimized to some extent in 2010 census data. This implies improvement in accuracy of age-sex data for Ghana.

4.4 Evaluation using the Graphical Method

The graphical method provides a quick idea about inaccuracies and biases in the age structure of any population. A particular and a common form of age misreporting is age heaping i.e. a noticeable concentration of reported ages at some specific digits. This is most frequently found at the ages ending with the digits 0 and 5. Age heaping is apparent when the single year age distribution is examined visually. Age heaping, however, is the result of preference for particular ages that end with particular digits. A graphical representation of the 2010 census of Ghana by age for males, females, and the total population are shown in Figures 4.3, 4.4 and 4.5.

Fig.4.3 Male Population by single Age.

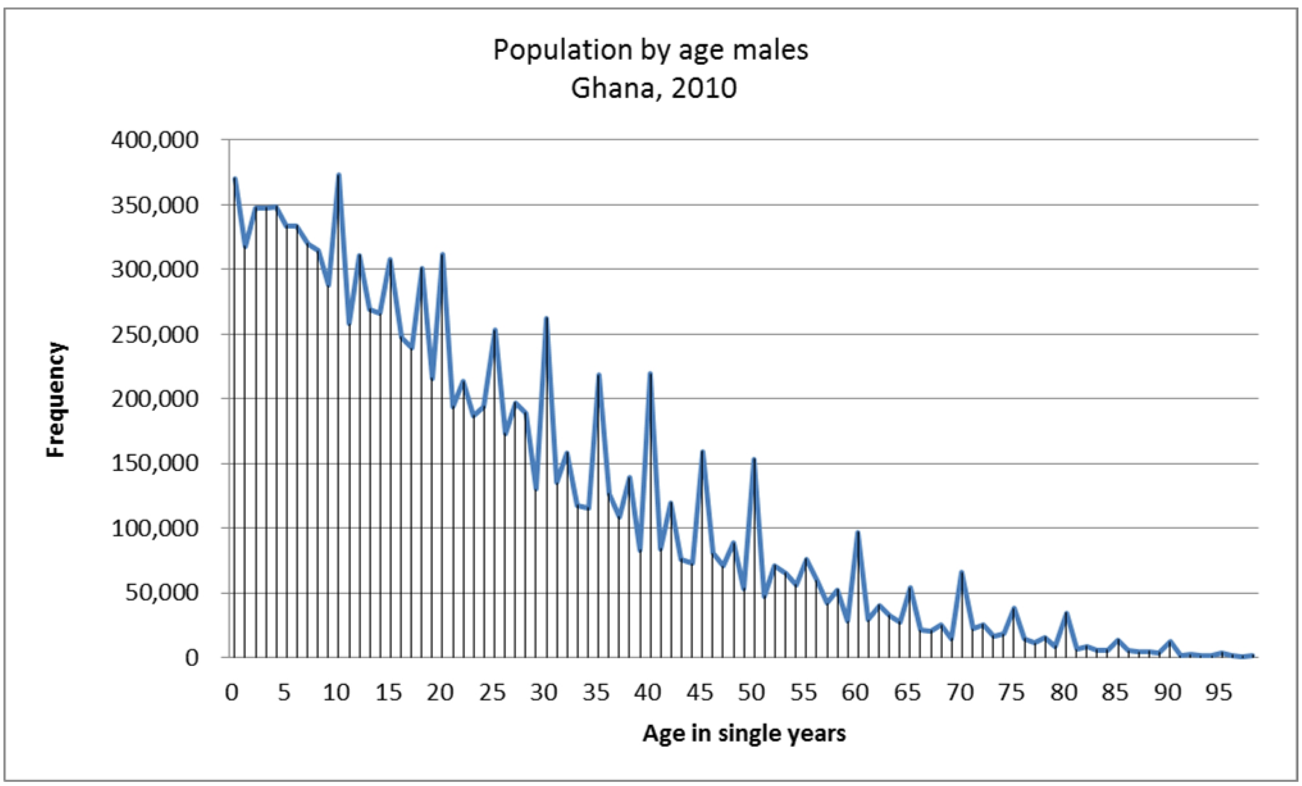


Fig.4.4 Female population by single Age

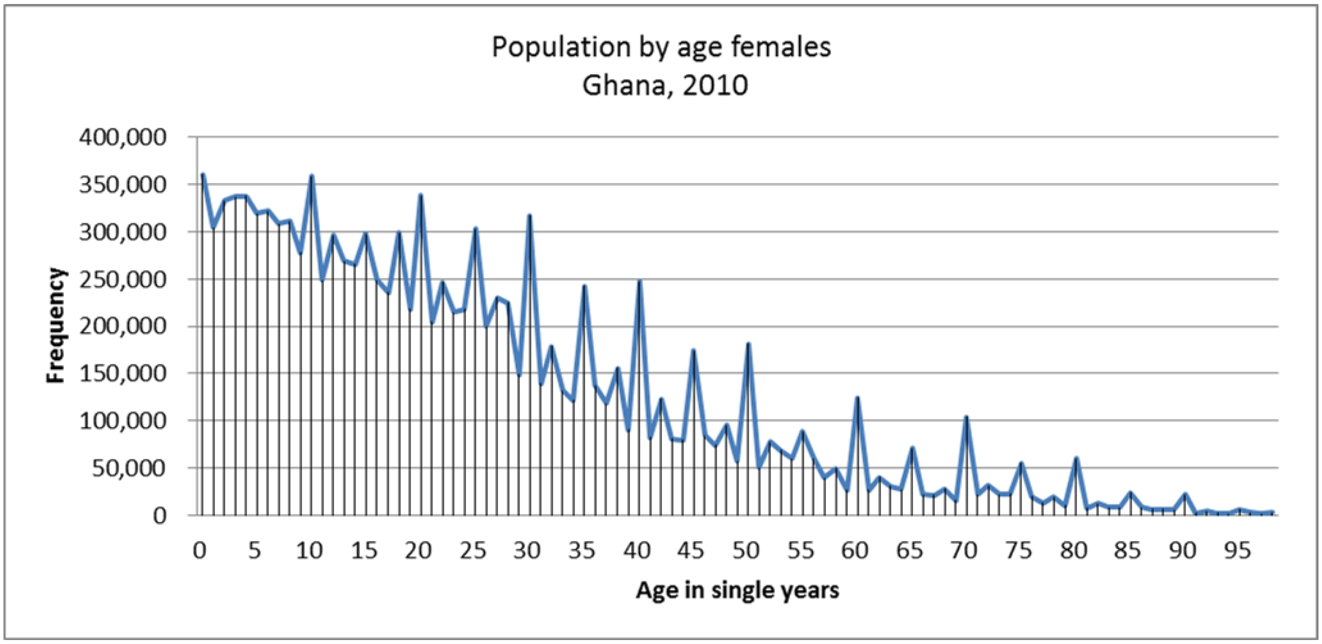
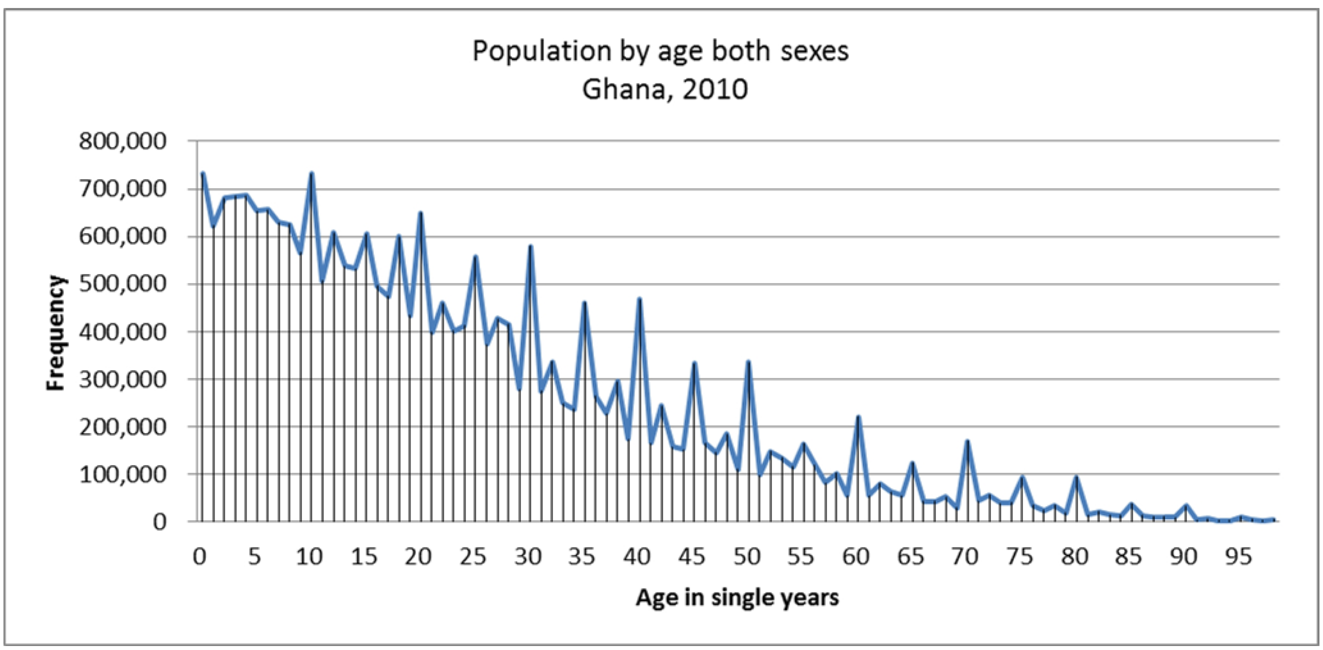


Fig.4.5.Total Population by Age- Ghana 2010.



A Visual inspection of the graphs, however, discloses the unusual concentrations at digits in 0 and 5 which show general preference for ages ending with those digits. Ages ending in digits with 1, 3, 7, and 9 are however, averted. The prevalence of these two situations is apparent for both males and females. In fact, the pattern for females seems to be slightly prominent than males. It is worthy to note that age 18 years is a very preferred age in Ghana, hence shows a high peak in the three figures shown above. This is due to the fact that it is the "assumed" adult age where citizens of Ghana are allowed to exercise their franchise by participating in national elections. There is therefore possible age shifting from ages 15, 16 and 17 resulting in heaping at 18years.

4.5 Evaluation using mathematical methods:

AGE RATIOS

Age ratios are used for data evaluation based on their vertical consistency. It is defined as the ratio of the population in a given age group to one half of the population in the two adjacent age groups multiplied by hundred. Like Sex ratio, Age ratios are based on the assumption that in the absence of errors in the age reporting, age ratios should be equal to hundred. This assumption of an expected value of 100 also implies that coverage errors are about the same from age group to age group and that age reporting errors for a particular group are offset by complementary errors in adjacent age groups. Age ratios, therefore, serve as a primary measure of net misreporting and should not be taken as errors for a particular age group. An overall measure of the accuracy of an age is the age- accuracy index and it is derived by taking the average deviation (irrespective of the sign) from 100 of the age ratio over all ages. The lower the age –accuracy index, the more reliable the census data on age appear to be. The age ratio and the age ratio score for males and females are shown in Table 4.4:

Table 4.4.Age Ratio, Age Ratio score and Age-Sex Accuracy Index .

AGE	AGE RATIO		DEVIATIONS FROM 100	
	Male	Female	Male	Female
5 -9	99.1	98.9	- 0.9	- 1.1
10 -14	101.9	101.4	1.9	1.4
15-19	101.7	97.6	1.7	- 2.4
20-24	97.7	101.7	- 2.3	1.7
25-29	99.8	104.9	- 0.2	4.9
30-34	97.6	96.0	- 2.4	- 4.0
35-39	99.3	99.1	- 0.7	- 0.9
40-44	101.4	99.8	1.4	- 0.2
45-49	93.7	92.2	- 6.3	- 7.8
50-54	110.9	116.9	10.9	16.9
55-59	83.2	77.1	-16.8	-22.9
60-64	115.0	117.7	15.6	17.7
65-69	72.4	70.0	-27.6	-30.0
Age Ratio scores:	**6.8**	**8.6**		
Age-Sex Accuracy Index:	**28.4**			

Source: Computed from the 2010 census data: Ghana

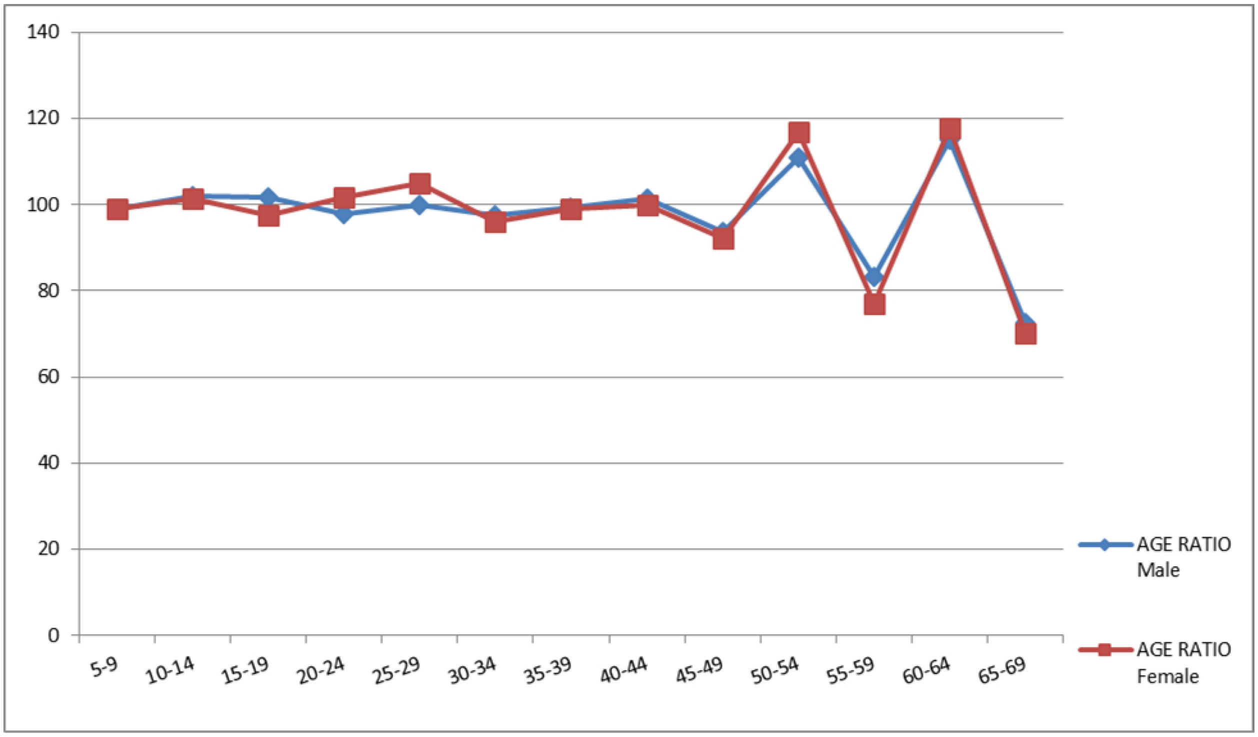
The female age structure appears to be more distorted than that of males. This assertion is confirmed by 8.6 age ratio score observed for females being higher than the 6.8 for men. This could be the plausibility of age misstatement among females than males.

Age ratios for both males and females within the 5-9 age groups are below 100. This does not suggest the omission of young children aged 0-4; rather there is the likelihood of a shift in age reporting from 5-9 groups to 10-14 due to misstatements of age. The age ratio for 15-19 for the female suggests that teenage single girls are graded downward in terms of their physical appearance. This results in the group losing some proportion of its members to the 10-14 age group, or the physiological characteristics of married teenage girls might result in shifting their ages upwards hence the surge in female age ratios for the age groups 20-29. This observation among the females confirm some of the patterns of age misreporting of women identified by Etiene van De Walle. He explained the phenomenon plausibly as "a quasi-universal tendency to assume a higher 'typical age of marriage than actually prevails (Van de Walle, 1968.p49). The wide fluctuation in the sex ratio after the reproductive period (50+) suggests that older women may be increasingly prone to recall lapse. Also high parity women are assigned higher ages. This also accounts for errors in age misreporting among females.

The pattern observed after the reproductive ages of women is virtually similar to what prevails in the pattern for men at those same ages. As the men advance in age from 50 years and beyond, some preferred to be seen younger whilst more also preferred to be seen older. These fluctuations results in peaks for the age groups 50-54 and 60-64 and troughs for 55-59 and 65-69. It is clear from fig 4.6 that from age 40 years and above, both men and women preferred digits ending in 0. In all, the deviations of the male age ratios from 100 are not as large as those of the females.

The results from table 4.4 are presented in a graphical form in figure 4.6.

Fig 4.6: Age Ratio by Age and sex-Ghana 2010



The points on the lines show the deviations from 100 resulting in the peaks and the troughs which are indications of marked age misreporting. The age groups 50-54 and 60-64 are highly exaggerated due to preferences for digits ending in 0. Critical assertion of the figure also reveals that females generally misreport their ages than their male counterparts.

As an extension of the data evaluation, the United Nations, however, proposed an **age/sex accuracy index** or **Joint Score** to further appraise data quality.

It is defined symbolically as 3 * **SRS + (ARS $_{(m)}$ + ARS $_{(f)}$).** Where (ARS $_{(m)}$ and ARS $_{(f)}$) are respectively the Age Ratio Score for males and females; and **SRS** is the Sex Ratio Score. The result of the calculated index is then interpreted as follows: If the Index is less than 20, it means the data are accurate; between 20 and 39 means the data are usable with adjustments; an index between 40 and 60 identified deficiencies in the data, hence the need to use with much care and caution with massive adjustment; but any derived index beyond 60 identify the data to be useless and need not be used at all.

The 2010 population census of Ghana had an accuracy index of 28.4 (Table 4.4) for its age and sex data. By the interpretation, the data are usable when adjustments are made. There is, however, an improvement over the previous census, which, according to (Gaisie, 2005) had an Accuracy Index of 36.0

4.6 OTHER INDICES:

Other notable mathematical methods of data evaluation are the use of the Whipple, the Myer's and the Bachi indices. These methods determine either the preference or avoidance for digits in the range 0-9.

4.6.1 The Whipple Index:

Table 4.5 presents the Whipple's Indices for Ghana's 2000 and 2010 censuses for the sexes by locality of residence. The computed National index for the 2000 data was 184 (176 for males and 192 for females). The value for the 2010 data, however, is 159 (155 for males and 163 for females). With locality of residence, the population living in urban areas had an index of 160 (156 for males and 165 for females) and rural is 206 (195 for males and 215 for females) in 2000. For 2010, the urban population had an index of 138 (137 for males and 140 for females) and rural 185 (178 for males and 191 for females. Though the 2010 data quality is an improvement upon the 2000, the former may be described to be rough and the latter very rough according to its measure. The data may not be as bad as the index indicated due to the fact that the Whipple index is a crude measure since it considered only heaping on digits 0 and 5.

Table 4.5. Whipple's Index for Ghana 2000 and 2010 (Place of residence and National).

	2000***			2010		
	MALE	FEMALE	BOTH SEXES	MALE	FEMALE	BOTH SEXES
URBAN	156	165	160	137	140	138
RURAL	195	215	206	178	191	185
NATIONAL	**176**	**192**	**184**	**155**	**163**	**159**

Source: Computed from the 2010 census data using PAS.

*** Ghana statistical Service, 2005.

4.6.2 The Myer's index.

Myer's index is another commonly used measure of age inaccuracy. It avoids a bit of bias found in the Whipple's index. The Myer's index shows the excess or deficit of people in ages ending in any of the 10 digits expressed as percentages. The theoretical range of Myer's index is from 0 to 180. The larger the value of the indices, the more preference, there are for certain digits. Values close to zero indicate no heaping, and 180 would result if all ages were reported only in ages ending in a single digit, say zero. The single year age distribution is depicted by the calculation of these indices. It is based on the assumption that the population is equally distributed among the ages, i.e., In the absence of known shifts in the annual number of births, deaths and immigration, the population size of adjacent ages should be rather similar. The indices are used to assess this assumption.

The Myer's blended indexes by sex and place of residence for 2000 and 2010 censuses' are shown in table 4.6 and 4.7:

Table 4.6. Myer's Indexes for Ghana by place of residence-total country, 2000 and 2010.

	2000			**2010**		
	MALE	**FEMALE**	**BOTH SEXES**	**MALE**	**FEMALE**	**BOTH SEXES**
URBAN	21.0	25.2	23.0	15.0	16.9	16.0
RURAL	33.7	41.4	37.5	27.8	32.9	30.4
NATIONAL	**27.6**	**33.6**	**30.6**	**20.8**	**24.0**	**22.5**

Source: computed from 2000 and 2010 censuses of Ghana.

The results of Myer's indexes for the two censuses in table 4.6 showed a marked improvement in data accuracy in 2010 as compared to 2000. In the two censuses, the male data showed a higher accuracy in age reporting than that for the females with respect to locality of residence (rural or urban) and at the national level. Also, residents in urban areas recorded a higher degree of accuracy in reporting their ages in the two censuses than residents in rural parts of the country.

Table 4.7. Pattern of Digit Preference for Ghana (Total population) from the Myers index analysis

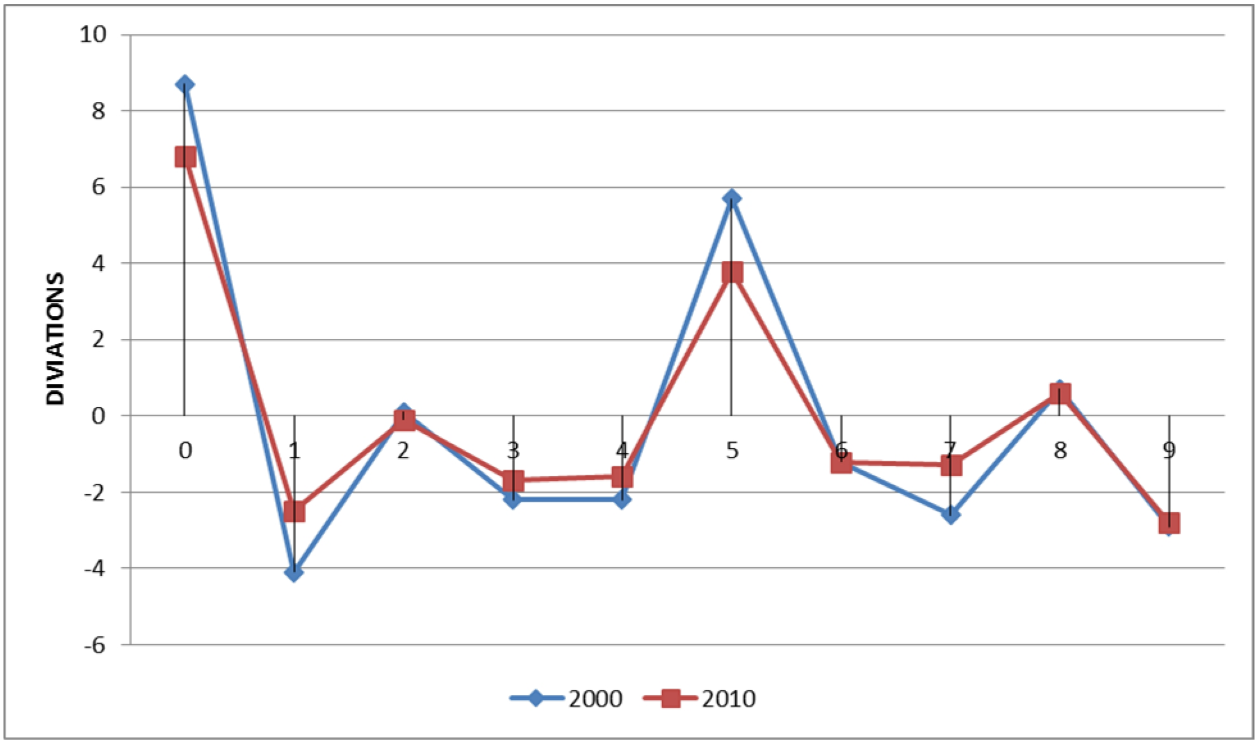
	2000		2010*	
DIGITS	PERCENT Of BLENDED	DEVIATIONS FROM 10	PERCENT OF BLENDED	DEVIATIONS FROM
0	18.7	8.7	16.8	6.8
1	5.9	- 4.1	7.5	- 2.5
2	10.1	0.1	9.9	- 0.1
3	7.8	- 2.2	8.3	- 1.7
4	7.8	- 2.2	8.4	- 1.6
5	15.7	5.7	13.8	3.8
6	8.8	- 1.2	8.8	- 1.2
7	7.4	- 2.6	8.7	- 1.3
8	10.7	0.7	10.6	0.6
9	7.1	- 2.9	7.2	- 2.8

Source: ** Computed from 2010 Population census data Using PAS.*

Table 4.7 shows the pattern of digit preference in the two censuses. Digits 0 and 5 are the most preferred. In 2000, 8.7 percent of the population preferred reporting on digits ending in 0 and 6.8 percent preferred reporting same digits in 2010. Similarly, 5.7 percent preferred digit 5 in 2000 with a corresponding 3.8 percent preference in 2010. The next preferred digits on which people reported their ages in the two censuses apart from 0 and 5 is 8. Though, the preferences for digits 0 and 5 show a decline, preference for digit 8 was almost the same in the two years under study. This might be due to the continuos preference for age 18 years (as indicated in Figures 4.3,4.4 and 4.5) which has so much influence on preference for digits ending in 8.

The deviations from Table 4.7 in the two censuses are presented in a graph in Figure 4.7 (Also see appendix F 3).

Fig4.7: Digit Preference for Ghana 2000 and 2010 (National).



Digits 9, 1, 3, 4, were avoided in the two censuses with no significant change in the avoidance of the digit 9 in the two censuses. Digit 6 also did not experience any change in its avoidance. The magnitude for the avoidance of digits 3 and 4 in the two censuses are almost at par for the two censuses. In all, the decreases shown in the magnitudes of preferences for some digits have confirmed an improvement in the 2010 data over that of the 2000.

Table 4.8 also presents the pattern of digit preference by sex. Females in the two censuses have a higher tendency to prefer digits ending in 0 and 5 than males. This is due to the fact that the tendency at which females prefer to report their ages ending in certain digits is higher than the male. On the other hand, males have higher tendency to avoid reporting their ages in digits ending with 1,3,4 and 7. Generally, preference for and avoidance of ages ending in particular digits had reduced in the 2010 census as compared to the 2000 census. This further affirmed the fact that the quality of data in the 2010 census had shown improvement upon the 2000 age data when one talks of age misstatement.

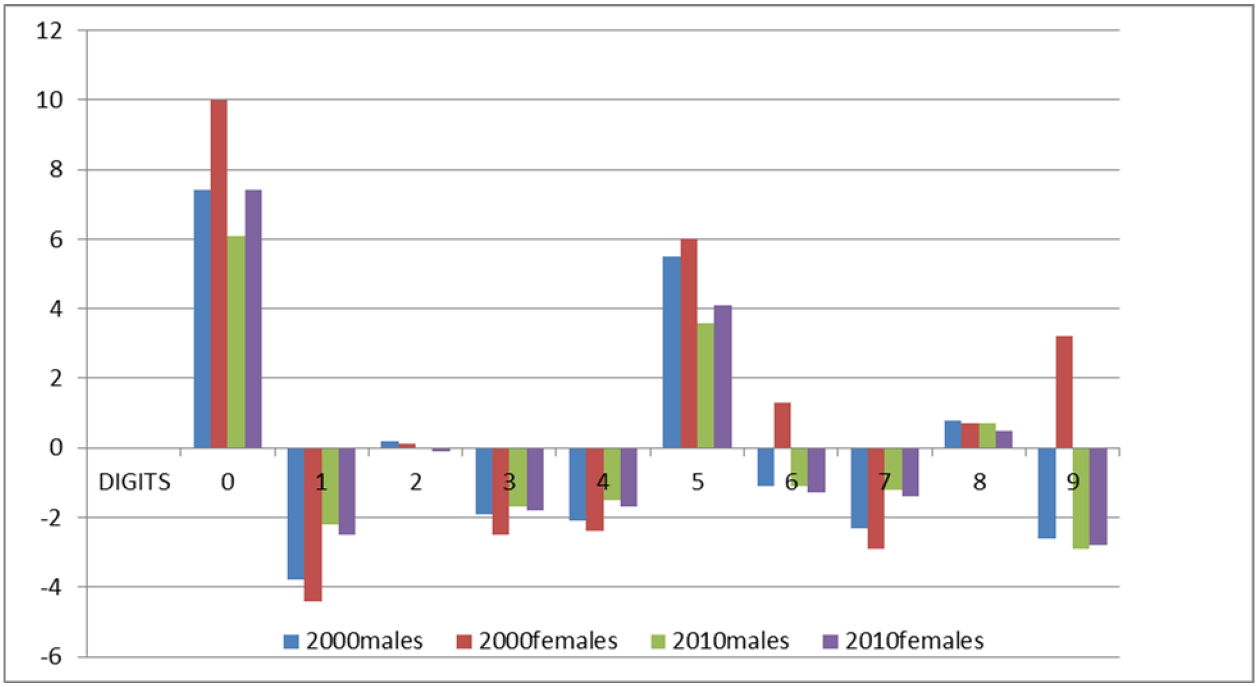
Table 4.8: Digit preference by sex-2000 and 2010 based on Myer's analysis

	2000		2010*	
DIGITS	MALE	FEMALE	MALE	FEMALE
0	7.4	10.0	6.1	7.4
1	- 3.8	- 4.4	- 2.2	- 2.8
2	0.2	0.1	0.0	- 0.1
3	- 1.9	- 2.5	- 1.7	- 1.8
4	- 2.1	- 2.4	- 1.5	- 1.7
5	5.5	6.0	3.6	4.1
6	- 1.1	1.3	- 1.1	- 1.3
7	- 2.3	- 2.9	- 1.2	- 1.4
8	0.8	0.7	0.7	0.5
9	- 2.6	3.2	- 2.7	- 2.9

Source: * *computed from the 2010 census data of Ghana using PAS.*

The preferences by the sexes in Table 4.8 in the two censuses are presented in a graph in Figure 4.8. Also see appendixes F 1 and F 2 for the procedures involve in its computation..

Fig 4.8 Digit preference by sex, 2000 and 2010



Source: *Derived from 2000 2010 census data from GSS.*

It is interesting to observe that the tendency females had for reporting ages ending with the digits 9 and 6 after 0 and 5 in the 2000 data had reversed to avoidance of these same digits in 2010. It is, however, clear that digit 8 is the next preferred digit after 0 and 5 for both sexes in the 2010 census. This could also mean that the tendency for females to misstate their ages had improved in 2010.

4.7: Locality of Residence and Digit Preference

The rural and urban preference for digits 0 and 5 showed that misstatement of age is about 50% better among the urban population than their rural counterparts. These might be due to the fact that there is increasing urbanization in Ghana. This made access to information possible through the electronic media about the essential information people were expected to provide during the census count. Table 4.9 explains the preferences for and avoidance of digits by place of residence in the 2000 and 2010 census: (See Appendix F- urban and Rural for details).

Table 4.9. Digit Preference by Place of Residence, 2000 and 2010.

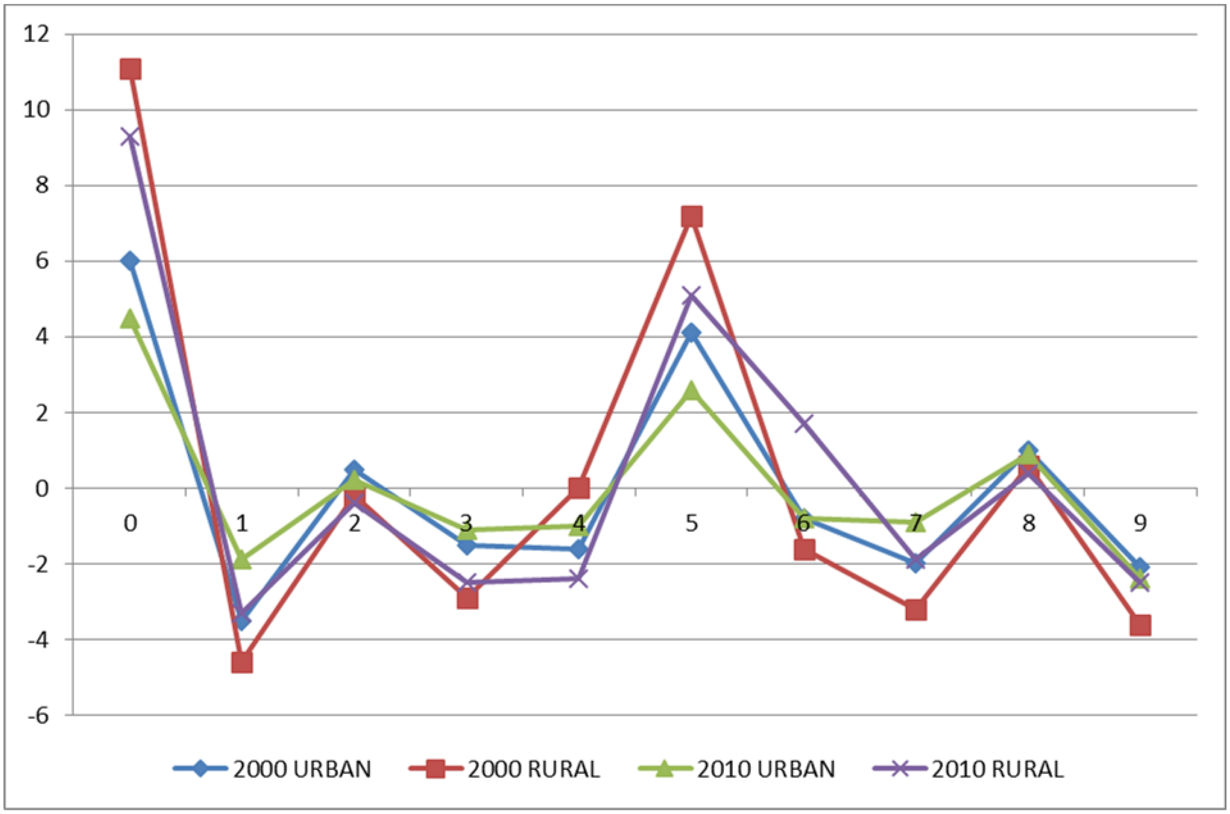
DIGITS	2000		2010*	
	URBAN	RURAL	URBAN	RURAL
0	6.0	11.1	4.5	9.5
1	- 3.5	- 4.6	- 1.9	- 3.3
2	0.5	- 0.2	0.2	- 0.4
3	- 1.5	- 2.9	- 1.1	- 2.5
4	- 1.6	- 2.8	- 1.0	- 2.3
5	4.1	7.2	2.6	5.3
6	- 0.8	- 1.6	- 0.8	-1.6
7	- 2.0	- 3.2	- 0.9	-1.9
8	1.0	0.6	0.7	0.5
9	- 2.1	- 3.6	- 2.4	- 3.3

Source: **Computed from 2010 census data using PAS.*

It could be observed from the table that age misstatement on any terminal digits in the two censuses showed much improvement for urban dwellers than their rural counterparts. An exception to this is the urban tendency to misreport their ages ending on digit 8 (0.7 urban; 0.5 rural) is 50% poorer than their rural counterparts. This possibly could be the influence 18 years have in Ghanaian society as the age of maturity (attainment of which citizens are allowed to vote). More urban teenagers have the tendency to misstate their ages than their rural counterparts do.

Figure 4.9 graphically present the results in Table 4.10. The peaks show the extent of misreporting. It can be observed that the peaks for the rural population in the two censuses are higher than the urban population except on digit 8 which showed higher preference for rural than urban.

Fig. 4.9 Digit Preference by place of residence for Ghana, 2000 and 2010.



4.8: Literacy and Digit preference

Adopting a "de facto"count (GSS, 2010), the 2010 population and housing census of Ghana enumerated individuals in households where they spent the census night (26th September 2010). Also, information on individuals was collected from heads of households or any adult member of the household that an individual belongs. This arrangement had created a situation whereby information is collected by proxy. Responses from proxy respondents might either be an approximation or a guess. Word and Robinson (2002) examined census data by type of enumeration method and concluded that there is no evidence of age heaping when ages are given out through self-response. This means that household heads in estimating age by proxy are likely to contribute to the exaggeration of ages of other household members whose ages are not known by the head. An attempt is, therefore, made here to examine whether a relationship exists between literacy and digit preference (on the basis of whether heads are literate or non-literate). The application of earlier methods was inconclusive in establishing a relationship between literacy of household heads and digit preference. The Bachi Index is therefore used in this regard. It is interpreted as the percent of respondents who actually wrongly reported their ages. This is because it measures the proportion of people who instead of reporting their ages on certain digits preferred other digits.

Table 4.10 presents digit preferences for Literate Heads of Household by Sex measured using the Bachi method. The mean absolute deviations obtained were 9.1 and 7.9 percent for male and female heads of households respectively. From the indices computed, it is clear that preference for ages ending in particular digits occur among males' more than female literate heads of households. The preferred digits are 0,5,8, and 2. The females on the other hand have a higher tendency to understate ages ending in digit 1 whilst the males have a higher tendency to understate ages ending in digits 3, 4, 6 and 7 as illustrated in Fig.4.10.

Table 4.10. Digit preference by Literate Heads of Household by sex

DIGITS	2010		
	Males	**Females**	**Both sexes**
0	4.7	4.2	4.5
1	- 1.6	- 2.0	- 1.7
2	0.7	0.5	0.6
3	- 1.5	- 1.0	- 1.3
4	- 1.6	- 1.3	- 1.5
5	2.4	2.1	2.3
6	- 0.6	- 0.4	- 0.6
7	- 1.4	- 0.9	- 1.3
8	0.9	0.8	0.9
9	- 2.9	- 2.7	- 2.8
Absolute Mean Deviations	**9.1**	**7.9**	**8.8**

Source: Computed from the 2010 Census Data using PAS.

A relationship, therefore, can be said to exist between literacy and digit preference considering the sex differentials, though the results did not show much difference. A plausible explanation of this is that men misreport their ages because of prestige where they want their ages to march their status in society. Figure 4.10 shows the preference and avoidance of the various digits.

Fig.4.10 Digit prefernce by Literate heads of households
(Bachi Method)

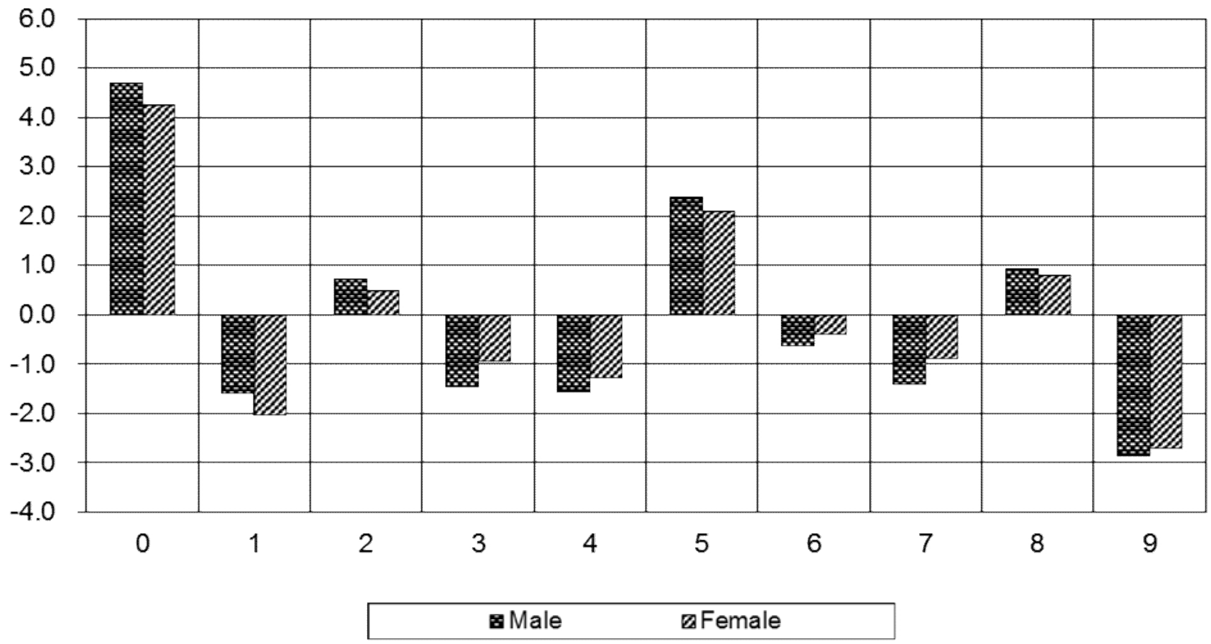


Table 4.11 presents the sex differentials of digit preference by literate and non literate heads of household using the Bachi Method. It is evident from the table that non-literate heads of households wrongly misreport their ages than literate heads of households. This however is more prevalent among men than women. About 26.4 percent of men and 26.1 percent of women instead of reporting their ages on certain digits preferred other digits. However, the preference for these digits varied between the sexes. Whilst more non- literate female heads preferred to report their ages ending in the digit 0 (18.1% females and 17.4males), more non-literate male heads also prefer to report their ages ending in the digits 5 (8.7% males and 7.6% females). It is also interesting to observe that the inclinations to report on digits ending in 8 and 2 are almost equal among both literate males and females whilst both non-literate males and females also

avoid reporting in digit 8 and 2. In totality, age reporting by literate heads of household is quite better than non literate heads.

According to the 2010 population census, 74.1 percent of the population 11 years and older are literate (GSS, 2012). In terms of sex, males (80.2 percent) are more likely to be literate, compared to females (68.5 percent). The report further indicated that the proportion of the population aged 15 years and older reported as literate increased from 54.1 percent in 2000 to 71.5 percent in 2010. This change is however in favour of females (19.6%) than for males (15.4%)

Table 4.11 Digit Preference by Literate and Non Literate Heads by Sex.

DIGITS	MALE		FEMALE	
	LITERATE	NON LITERATE	LITERATE	NON LITERATE
0	**4.7**	**17.4**	**4.2**	**18.1**
1	- 1.6	- 4.5	- 2.0	- 4.9
2	0.7	- 0.9	0.5	- 0.6
3	- 1.5	- 4.2	- 1.0	- 3.6
4	- 1.6	- 4.5	- 1.3	- 3.8
5	**2.4**	**8.7**	**2.1**	**7.6**
6	- 0.6	3.3	0.4	- 3.0
7	- 1.4	- 3.6	- 0.9	- 4.0
8	**0.9**	**- 1.1**	**0.8**	**- 1.3**
9	- 2.9	- 4.5	- 2.7	- 5.2
Absolute Mean Deviations	**13.0**	**26.4**	**14.1**	**26.1**

Source: computed from the 2010 population census data using PAS.

4.9. Use of Demographic Models.

Demographic models are used to determine irregularities that occur in age-sex data due to age heaping by appraising the quality of such data. Models can be conceived as a simplified description of a system that assists calculations and predictions. In demography, there now exist, a number of descriptive models (Newell, 1988). The most widely used are those concerns with the age structure and the characteristics of this make them more predictable. The predictability of these demographic phenomena makes them suitable for modeling. Demographic models used in this study to appraise data quality of Ghana's 2010 population and housing census are the intercensal growth rate and Cohort survival ratio methods.

4.9.1. Intercensal Growth Rate

This method involves computing the growth rates using the 5 year age group data for two or more censuses, based on the exponential growth law which views change as occurring continuously rather than at discrete intervals. The growth rates for the specific age groups are expected to be close to the total growth rate. Any deviation from the overall growth rate suggests errors due to possibility of neither net over or under enumeration. Table 4.12 presents the age specific intercensal growth rates for Ghana.

The low growth rates for the age group 5-9 (1.2) suggest either high effect of mortality on that age group or possible under misstatement of the ages of those belonging to that cohort. The age groups in the range 15-39 have experienced very high growth rates over the intercensal period for both males and females. This could account for the youthful nature of Ghana's population structure in recent times. However, whilst the growth rate of the female stabilized at 3.2 percent for the cohort 40-44, the male cohort experienced a decline in its growth from 3.2 to 2.6 percent and further declined to 1.8% for its 45-49 cohorts. This decline in the growth rates for males might be due to effects of mortality in those cohorts in favour of females or the likelihood of enumerating some of the cohort members in the adjacent age groups which could plausibly result from misstatement of ages. The high intercensal growth rate in the population of females rose to 3.5 % for the 45-49 cohorts to unprecedented growth rate of 4.5% in her 55-59 cohort. The male cohorts 50-59 also, though experienced a high growth rate of 3.5% on average is lower when compared to what the female cohort experienced. There is the likelihood of understatement of ages among the 60-64 cohort for both males and females resulting in higher growth rates experienced in the 55-59 cohorts.

One should also not forget that the high growth rates among the 20-39 cohorts, especially among the female population could plausibly be the result of immigration of Ghanaians from the La' Cote d'Ivoire. Ghanaian women are noted for migrating to that country, for some commercial activities over the years. But before the 2010 census, La Cote d'Ivoire experienced some political turmoil which resulted in emigration of people from that country into Ghana as refugees as well as some Ghanaian nationals coming back as returnees.

Table 4.12: Intercensal Age Specific Growth Rate by Sex, Ghana, 2000 - 2010

	2000			**2010**			GROWTH RATE		
	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL
0 - 4	1,379,770	1,389,651	2,769,421	1,731,787	1,673,619	3,405,406	2.3	1.9	2.1
5 - 9	1,390,652	1,384,554	2,775,206	1,589,632	1,539,320	3,128,952	1.3	1.1	1.2
10-14	1,151,131	1,111,085	2,262,216	1,477,525	1,438,515	2,916,040	2.5	2.6	2.5
15-19	961,162	922,591	1,883,753	1,311,112	1,298,877	2,609,989	3.1	3.4	3.3
20-24	763,051	837,769	1,600,820	1,100,727	1,222,764	2,323,491	3.7	3.8	3.7
25-29	695,494	791,805	1,487,299	943,213	1,106,898	2,050,111	3.0	3.4	3.2
30-34	566,439	640,370	1,206,809	790,301	888,508	1,678,809	3.3	3.3	3.3
35-39	490,864	538,901	1,029,765	676,768	744,635	1,421,403	3.2	3.2	3.2
40-44	443,284	443,647	886,931	572,620	613,730	1,186,350	2.6	3.2	2.9
45-49	377,315	343,042	720,357	452,975	485,123	938,098	1.8	3.5	2.6
50-54	279,950	288,419	568,369	394,600	438,498	833,098	3.4	4.2	3.8
55-59	182,843	172,999	355,842	258,582	265,113	523,695	3.5	4.3	3.9
60-64	177,347	189,004	366,351	227,050	248,799	475,849	2.5	2.7	2.6
65-69	129,090	129,619	258,709	136,244	157,627	293,871	0.5	2.0	1.3
70-74	106,513	118,645	225,158	149,512	201,818	351,330	3.4	5.3	4.4
75 +	262,477	252,596	515,073	212,197	310,134	522,331	-2.1	2.1	0.1
TOTAL	9,357,382	9,554,697	18,912,079	12,024,845	12,633,978	24,658,823	2.5	2.8	2.7

Source: Computed from the 2000 and 2010 Grouped Age-Sex data

4.9.2 Application of Cohort Survival Ratio

Table 4.13 exemplifies the survival ratios for Ghana between 2000 and 2010. The high rate above unity for age group 10-14 might possibly be due to age misstatement of children who belonged to 0-4 age group in the 2000 census. The high survival ratio above unity for age groups in the 20-34 range plausibly could be due to the effect of immigration on the population. Also, the observed fluctuations in the ratio for age groups from 35 to 54 could plausibly be due misstatement of age or migration. It is also clear from the table that about 96 percent of those enumerated in the 2010 census were survivors from and were also enumerated during the 2000 census of Ghana.

The interpretation of this in terms of data quality is that, in the absence of census errors, the ratio of the number of persons in a birth cohort enumerated in the first census should approximate the survival ratio that would be expected on the basis of the prevailing mortality conditions.

Table 4.13. Intercensal Survival ratio for Ghana. 2000 and 2010.

AGE GROUP/YEAR		ENUMERATED		SURVIVAL RATIO
2000	**2010**	**2000**	**2010**	
0-4	10-14	2769421	2916040	1.0529
5-9	15-19	2775206	2609989	0.9405
10-14	20-24	2262216	2323491	1.0271
15-19	25-29	1883753	2050111	1.0883
20-24	30-34	1600820	1678809	1.0487
25-29	35-39	1487299	1421403	0.9557
30-34	40-44	1206809	1186350	0.9830
35-39	45-49	1029765	938098	0.9110
40-44	50-54	886931	833098	0.9393
45-49	55-59	720357	523695	0.7270
50-54	60-64	568369	475849	0.8372
55-59	65-69	355842	293871	0.8258
60-64	70-74	366351	351330	0.9590
65+	75+	998940	522331	0.5229
TOTAL		**18912079**	**18124465**	**0.9584****

Source: Computed from the 2000 and 2010 population census data.

CHAPTER FIVE

SMOOTHING AND ADJUSTMENT OF DATA

5.1. Introduction

On the basis of the evidences adduced using the various evaluation techniques, it is clear that the reported age distributions of the enumerated populations in the 2010 population and housing census of Ghana is not without errors. As noted earlier, these errors were due to inaccurate reporting of ages in the population sub groups. In the case of errors which substantially affect one or more of these subgroups, at least a rough adjustment is necessary if useful population projections are to be obtained. If this is not done, however, the errors will be carried forward for a decade or more, and every year there will be an overstatement of some cohorts and understatement of others.

The adjustment is expected to remove possible errors in the age sex data. To achieve this, the appropriate technique needs to be chosen based on the type and magnitude of the errors detected. Several methods were, however, available in the *AGESMTH* spreadsheets. These are (1) Carrier-Farrag, (2) Karrup-king Newton, (3) United Nations, (4) Arriaga, and (5) Strong moving average.

5.2. Adjustment of the Age Distribution.

The age data from Ghana's 2010 census was adjusted using the techniques mentioned in the previous page (page 54). Among the five techniques mentioned, Karup-King, UN, and Carrier-Farrag procedures adjust for ages 10-69. Each of these techniques has some underlying suppositions.

The United Nations procedure assumes that, net gains and losses of alternate age groups are constant. Five different ages are used to obtain an adjusted/smoothed age for the middle age group. Carrier-Farrag procedure on the other hand assumed that the relationship of a five year age group to its component 10 year group is an average of a similar relationship in three successive 10 year age groups. Karup-King like the other two techniques accept the enumerated population in each ten year age group hence producing similar results. Based on these assumptions and differences in techniques, the UN, Carrier-Farrag and Karup-King procedures cannot smooth or adjust for the age groups 0-9.

Arriaga and Strong techniques on the other hand adjust for ages 0-79 (i.e adjusting for all age groups). The strong technique is used in situations where there are serious age misreporting errors that require a more robust technique of adjustment.

Table 5.1 presents the reported and smoothed population for the five adjusting techniques in absolute figures. Arriaga and Strong techniques distinguish themselves for adjusting for all age groups against Carrier- Ferrang, Karup- king Newton and the United Nations techniques (which could not adjust for age group 0-9 years). The total population obtained under each smoothing technique indicate that Arriaga and Strong technique again produced results close to the total enumerated/reported population.

Table 5.1:Reported and Smoothed population, indicating the various techniques in the AGESMTH

Age	Reported	Smoothed				
		Carrier Farrag	Karup.-King Newton	Arriaga	United Nation	Strong
Total **0-79**	**24,342,445**			**24,342,445**		**24,342,445**
Total **10-69**	**17,250,804**	**17,250,804**	**17,250,804**	**17,250,804**	**17,268,654**	**17,250,804**
0-4	3,405,406			3,387,216		3,404,439
5-9	3,128,952			3,147,142		3,129,919
10-14	2,916,040	2,901,563	2,898,062	2,901,064	2,899,204	2,854,289
15-19	2,609,989	2,624,466	2,627,967	2,624,965	2,617,434	2,573,115
20-24	2,323,491	2,344,523	2,338,415	2,340,935	2,330,029	2,290,435
25-29	2,050,111	2,029,079	2,035,187	2,032,667	2,029,932	2,003,401
30-34	1,678,809	1,689,639	1,690,678	1,684,478	1,697,769	1,699,583
35-39	1,421,403	1,410,573	1,409,534	1,415,734	1,417,904	1,438,837
40-44	1,186,350	1,171,556	1,171,188	1,166,852	1,174,350	1,180,753
45-49	938,098	952,892	953,260	957,596	969,605	970,905
50-54	833,098	764,029	763,067	759,305	782,247	769,249
55-59	523,695	592,764	593,726	597,488	577,548	616,704
60-64	475,849	427,491	434,829	427,024	427,770	473,639
65-69	293,871	342,229	334,891	342,696	344,861	379,895
70-74	351,330			289,586		305,833
75-79	205,953			267,697		251,450
80+	316,378					
Total	**24,658,823**	**17,250,804**	**17,250,804**	**24,342,445**	**17,268,654**	**24,342,445**

Source: Computed from the 2010 census data using PAS.

Table 5.2 presents the reported populations for the 2010 census in percentages. The percentages were calculated for each age group under the various adjusting techniques. Absolute differences in the values of the various adjusted techniques were then calculated. The adjusted population obtained by Karup King, Farrag, and UN techniques is higher than the reported. The smoothed population obtained by Arriaga and Strong procedures is very close to the reported proportion. But the justification for the use of the Strong technique to adjust the age-sex data of the 2010 population and housing census is based on the robustness it has exhibited when the dissimilarity index is computed for all the techniques.

Table 5.2: Reported Population (%) and absolute deviations of smoothed from reported.

AGE	Reported	Carrier Farrag	Newton	Arriaga	United Nations	Strong
0-4	13.81			0.10		0.18
5-9	12.69			0.24		0.17
10-14	11.83	4.99	4.97	0.09	4.96	0.10
15-19	10.58	4.63	4.65	0.20	4.57	0.01
20-24	9.42	4.17	4.13	0.19	4.07	0.01
25-29	8.31	3.45	3.48	0.04	3.44	0.08
30-34	6.81	2.99	2.99	0.11	3.02	0.17
35-39	5.76	2.41	2.41	0.05	2.45	0.15
40-44	4.81	1.98	1.98	0.02	1.99	0.04
45-49	3.80	1.72	1.72	0.13	1.81	0.18
50-54	3.38	1.05	1.04	0.26	1.15	0.22
55-59	2.12	1.31	1.32	0.33	1.22	0.41
60-64	1.93	0.55	0.59	0.18	0.55	0.02
65-69	1.19	0.79	0.75	0.22	0.81	0.37
70-74	1.42			0.24		0.17
75-79	0.84			0.26		0.20
80+	1.28					
Total	100.00	30.04	30.04	2.66	30.04	2.48
Dissimilarity Index		**15.02**	**15.02**	**1.33**	**15.02**	**1.24**

Source: computed from 2010 Population Census Data of Ghana.

The Index of dissimilarity computed for the smoothed population is the sum of the absolute differences between the percentages for each age group divided by one-half. The calculated indexes are shown in table 5.2. The Strong smoothening technique proved to be the best for adjusting the 2010 census data based on the fact that the magnitude of the error is extremely rough and that the computed index of dissimilarity has produced a better index compared to the other four techniques.

5.3 Reported and Adjusted population

As noted earlier, subjecting the graduated figures to scrutiny indicate that the Strong smoothing technique is the most robust among the five because it is consistent with the reported age distribution by sex. The method eliminated the under enumeration in the 5-9 age group and age heaping errors especially on digits ending in 0.

Table 5.3 denotes the ratio of reported and adjusted age distributions by sex in Ghana using the 2010 population census data. The computed ratio of reported to adjusted for both males and females expresses the relative size of the two values. The deviation of the ratios from unity indicates the extent of misreporting error in the age distribution. Ratios above unity imply over statement of the ages. The converse is true for ratios that are below unity.

Deviations of the ratios from one and its subsequent conversion to percentages indicate the extent of errors in the age distributions for the various sexes. The male population in the 0-4 age is observed to be lower than expected. This might be due to 0.31 percent under statement of the age of the cohort, especially those less than one year old could be omitted and those four years old enumerated as five years old in the 5-9 cohort. These plausible situations have actually reflected the 0.34 percent excess in the 5-9 age groups for the males. The excess above unity recorded for both males and females in the 10-14 age groups indicate the understatement of age of that cohort in the 2000 census (when the cohort was 0-4). Also, 0.17 percent of the population in the 15-19 age group could plausibly be enumerated as part of the 20-24 age group plausibly because of their physiological appearance that result in the overestimation of their ages in the absence of their birth certificates or Health insurance cards.

Table 5.3: Ratio of reported to adjusted Age Distribution by Sex (Based on Strong Technique)-Ghana 2010.

AGE GROUP	REPORTED		ADJUSTED		RATIO OF REPORTED TO ADJUSTED	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
0 - 4	1731787	1673619	1737100	1667362	**0.9969**	**1.0038**
5 - 9	1589632	1539320	1584319	1545577	**1.0034**	**0.9960**
10 - 14	1477525	1438515	1430577	1423654	**1.0328**	**1.0104**
15 - 19	1311112	1298877	1272023	1301046	**1.0307**	**0.9983**
20 - 24	1100727	1222764	1105250	1185188	**0.9959**	**1.0317**
25 - 29	943213	1106898	955440	1047979	**0.9872**	**1.0562**
30 - 34	790301	888508	803180	896427	**0.9840**	**0.9912**
35 - 39	676768	744635	679601	759258	**0.9958**	**0.9807**
40-44	572620	613730	564366	616395	**1.0146**	**0.9957**
45-49	452975	485123	465892	505018	**0.9723**	**0.9606**
50 - 54	394600	438498	370190	399062	**1.0659**	**1.0988**
55 - 59	258582	265113	295481	321226	**0.8751**	**0.8253**
60 - 64	227050	248799	224362	249286	**1.0120**	**0.9980**
65 -69	136244	157627	175356	204547	**0.7770**	**0.7706**
70 - 74	149512	201818	135092	170744	**1.1067**	**1.1820**
75+	212197	310134	103569	147878	**2.0488**	**2.0972**
Total	**12024845**	**12633978**	**11901798**	**12440647**	**16.8992**	**16.9966**

Source: Computed from the 2010 Population Census Data.

About 3.1 percent of the males in the cohort 15-19 overstate their ages. This could be the result of them looking younger than their ages in terms of their physical appearance even at the attainment of adolescents. There is also the overstatement of the ages of the female age group 25-29 by 5.6 percent more than what is expected. A plausible explanation of this pattern of age misreporting of women could be due to exaggeration from the reference point. This could be by successive transfers according to whom the age of a mother is computed from the normal age of marriage by adding the number of children and a standard interval between births (Van de Walle, 1968. p49). The ratio above unity recorded for males within 40-44 and 50-54 for both sexes, could be due to transfers from the adjoining age groups. About 1.5 percent of males in the 40-44 cohorts were shifted from the adjoining age groups. For 50-54 age groups, the males recorded 6.6 percent above unity whilst the female 9.9 percent. This might also be due to an under enumeration of the preceding and succeeding cohorts due to over statement and understatement of their ages respectively. For other ages, (Gaisie 2005) observed that age misreporting is widespread among persons 55 years and older. There is the tendency to overstate age by males and understate ages by females. The women sometimes are prone to recall lapses.

5.4: Substance of the adjusted 2010 Census Data.

The utility and need for census data are high in a country like Ghana where there is no regular household survey programme and vital registration system. This data source is the primary source of national level data about the size and characteristics of its population. The Census, being the largest and most significant statistical activity undertaken in the country is expected to provide the Government of Ghana and its development partners with detailed demographic data for every region, metropolitan, municipality and district assemblies. The provision of this vital information and data is central to the country's planning for development programmes. Quality data and indicators are particularly valued and crucial in areas such as

- Planning, implementation and monitoring of all development programmes in the country, and information to track progress towards the Millennium Development Goals (MDGs).

The data on population size, growth, composition and distribution provide the most important and critical inputs to the preparation of demand projections for food, clothing, shelter, nutrition and healthcare, education, employment and assessment of various other basic requirements.

Based on these facts, there is the need to determine the reliability and acceptability of the adjusted age-sex data (see appendixes D and E) for age and sex ratio of reported and adjusted populations).

The summary of the indices measuring the accuracy of adjusted and reported data is presented in Table 5.4. Which is an extract from *PAS output 'B' of AGESMTH.*

Table 5.4: Summary of Indices Measuring the Accuracy of Adjusted 2010 population Census data of Ghana.

INDEX	REPORTED	ADJUSTED
Sex Ratio Score	4.43	1.93
Age Ratio Score (Males)	5.79	1.34
Age Ratio Score (Females)	7.92	1.55
Age Accuracy Index	26.71	8.99

Source: Computed from the 2010 Population Census data using PAS

Note: The accuracy index is the sum of the male and female age ratio scores plus three times the sex ratio score, all calculated using data for ages 10-14 through 65-69.

The low sex ratio of the adjusted population data is an indication that the adjustment yielded a horizontal improvement in the data. The computed age ratio scores represent a vertical consistency check on the accuracy of the 2010 census data. The low adjusted age ratio scores for both males and females in contrast to the age ratio scores of the reported data suggest that the distortions in the adjusted data have been minimized.

Last but not the least, the United Nations accuracy index of 8.99 for the adjusted is indicative of the fact that the Strong Smoothing technique applied to the data is the most appropriate.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1. Summary

Setting out the objective to evaluate and adjust the age and sex data of the 2010 Population and Housing Census of Ghana, the study sought to determine the nature of error in the data. Several data evaluation techniques were used to examine the errors in the reported data. Among the techniques employed were the graphical, mathematical and demographic models.

The sex ratio obtained was 95.2 males per 100 females and this was consistent with the low rate that prevails in other African countries and found to be within the generally accepted range of 95 to 100 males per 100 females in a developing country. The sex ratio from the ten administrative regions of Ghana showed a general decline from that of the year 2000 as reflected in the general sex ratio for the 10 administrative regions in the country except the Upper East and West regions. The declining sex ratios experienced in the country over the period were significant in the Ashanti, Greater Accra and Western regions culminating in their rates falling below the national average. This could be plausibly due to more female migration into these regions the capitals of which are the three most important in terms of commerce in Ghana. Western Region experienced an unprecedented decline from a record high of 103.2 to 100 males per 100 females. The change in the age-sex structure of the Western Region is beginning to impact morbidity where the region's HIV prevalence rate is reported to have increased from 1.9% in 2011 to 2.4% in 2012 (Ghanaian Times, 2013).

Age heaping is seen to be apparent when single year age distribution is examined visually and or graphed. There was the disclosure of unusual concentrations of ages ending in 0 and 5 which are shown on the graphs by peaks and avoided digits shown by troughs. Age 18 however, is observed in the graph to show a peak almost close to age 20. The preference for age 18 might be due to the fact that it is the age at which the constitution of the country qualifies her citizens to exercise their franchise by participating in national elections through voting. There is therefore the tendency for teenagers to misreport their age to acquire the voter identity card which is also used for other transactions.

Digit preference due to misstatement of ages at the national level was higher among females (24%) than males (20%). This made the female data less accurate than the males. In a similar vein, the accuracy of age data for the population in urban areas (16.0) of Ghana is higher than the accuracy of the data for the rural (30.4%) population. In terms of relationship between literacy and digit preference, literate heads of household report more accurate (13% for males; and 14.1% for females) than non-literate heads of household (23.4% for males and 26.1% for females). A relationship, therefore, exists between literacy and age misstatement.

A study of digit preference at various levels showed the overstatement of ages ending in preferred digits and the corresponding underreporting of ages ending in the averted digits.

A characteristic pattern of digit preference is therefore generated. The greatest heaping occurs on ages ending in 0, the second preference has been for ages ending in 5, and a third but much lower is observed on ages with even numbered terminal digits 8 and 2. According to Stockwell (1966), since digits 6 and 4 flank the even more preferred digit 5, they attract less heaping than the digits

8 and 2. This means that ages ending in 1,3,7, and 9 are noticeably under-reported. As 1 and 9 flank the most preferred digit 0, they were under-stated to a greater extent than the digit 3 and 7.

The intercensal age specific growth rate also explained how the population aged 15 to 39 had experienced tremendous growth over the two period giving rises to the youthful nature of Ghana's population. The survival ratio also reveals that about 96 percent of the population enumerated in the 2010 census was survivors who were also enumerated in the 2000 census as well. In all, there had been an improvement in the age data of the 2010 census when compared to the 2000 census.

Finally, a more robust smoothing technique was chosen by computing an Index of Dissimilarity (a standardization technique) to adjust the reported data, making it more credible for use in projections for policy decisions.

6.2 Recommendations

Though a lot of progress had been made to ensure the collection of accurate age data over the years, there is much room for improvement as there are policies and programmes that assume wide coverage and can capture the date of birth of respondents in future censuses/surveys. Some of these programmes/policies are the issuance of health insurance and voter identity cards which contain information on holders' date of birth. Also, there is free registration of birth of infants who are 1 year and below. These programmes need to be adopted as part of national programmes to enhance the civil registration system in Ghana. With these, it is expedient on the part of the Ghana Statistical Service to train its data collection officers to record the date of birth of the respondents from any of these cards or certificate. The recorded date of birth should then be used to calculate the age by the interviewers/enumerators.

Also, to achieve more accurate collection of age data, the Ghana Statistical Service should partner the Birth and Death Registry to strengthen the civil registration system. This can however be achieved through amendments to the laws that establish the two institutions by a legislative instrument.

Also, the GSS should always sensitize her trained field staff on digit preference and how it impacts data quality. These when done would always make the interviewers cautious when estimating ages for respondents and other household members.

Interviewers should also be trained in recall techniques (e.g. the use of life history and community calendars) in obtaining exact ages.

That is not all, the GSS should explore possible ways of introducing self administered questionnaire to households that have the head and/ or other responsible members literate since there is enough evidence that there is no evidence of age heaping when the forms are filled out through self-response.

These measures when put in place can go a long way to enhance age data quality in censuses and surveys in Ghana.

6.3 Conclusion

Age misreporting is not an end in itself, but a means to understanding its implications. Although the Ghana Statistical Service from time to time put in measures to minimize age misstatements in its surveys and censuses, there is the need for government to step in and formulate policies to include dates of births on any identity card that is issued in the country by any agency or institution (e.g ., Voter ID, National ID card, etc). When this is done, it can serve as a guide to enumerators working on any data collection exercise to estimate ages of their respondents very well. This in the long run can improve data quality in surveys and censuses.

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APPENDIX A

Single Year Age Data for Ghana-2010

Age	Total	Male	Female	Age	Total	Male	Female
Total	24,658,823	12,024,845	12,633,978				
0	731,201	370,320	360,881	50	335,273	153,519	181,754
1	622,871	318,102	304,769	51	98,454	47,766	50,688
2	680,641	347,452	333,189	52	148,808	71,506	77,302
3	684,823	347,482	337,341	53	134,533	65,514	69,019
4	685,870	348,431	337,439	54	116,030	56,295	59,735
5	653,006	333,619	319,387	55	164,660	76,030	88,630
6	656,286	333,999	322,287	56	119,741	59,892	59,849
7	629,007	320,142	308,865	57	81,770	41,863	39,907
8	625,319	314,306	311,013	58	102,315	52,365	49,950
9	565,334	287,566	277,768	59	55,209	28,432	26,777
10	731,610	372,896	358,714	60	221,708	97,144	124,564
11	506,549	258,049	248,500	61	55,469	29,020	26,449
12	607,796	311,144	296,652	62	80,380	40,429	39,951
13	538,356	269,397	268,959	63	63,296	32,838	30,458
14	531,729	266,039	265,690	64	54,996	27,619	27,377
15	605,337	307,502	297,835	65	124,538	53,796	70,742
16	496,123	247,471	248,652	66	43,228	21,131	22,097
17	474,666	239,108	235,558	67	42,573	21,039	21,534
18	599,926	301,233	298,693	68	53,220	25,510	27,710
19	433,937	215,798	218,139	69	30,312	14,768	15,544
20	650,177	311,587	338,590	70	170,366	66,051	104,315
21	398,945	194,208	204,737	71	44,162	22,177	21,985
22	460,099	213,422	246,677	72	57,196	25,829	31,367
23	401,890	187,391	214,499	73	38,695	16,996	21,699
24	412,380	194,119	218,261	74	40,911	18,459	22,452
25	556,140	253,126	303,014	75	93,439	38,355	55,084
26	373,308	173,318	199,990	76	34,621	15,033	19,588
27	427,358	197,261	230,097	77	24,228	11,200	13,028
28	414,518	189,384	225,134	78	34,680	15,798	18,882
29	278,787	130,124	148,663	79	18,985	8,763	10,222
30	579,941	262,693	317,248	80	94,740	34,546	60,194
31	274,835	135,380	139,455	81	14,390	6,668	7,722
32	336,958	158,441	178,517	82	21,499	9,133	12,366
33	249,483	117,818	131,665	83	14,341	6,124	8,217
34	237,592	115,969	121,623	84	14,114	5,886	8,228
35	461,027	218,355	242,672	85	37,902	13,928	23,974
36	264,250	126,854	137,396	86	13,613	5,457	8,156
37	227,508	109,032	118,476	87	10,849	4,591	6,258
38	294,871	139,109	155,762	88	11,106	4,756	6,350
39	173,747	83,418	90,329	89	9,600	4,205	5,395
40	467,054	219,610	247,444	90	34,228	12,233	21,995
41	166,202	84,044	82,158	91	4,098	1,739	2,359
42	243,400	119,985	123,415	92	6,388	2,442	3,946
43	157,462	76,177	81,285	93	3,258	1,317	1,941
44	152,232	72,804	79,428	94	3,109	1,273	1,836
45	333,095	159,271	173,824	95	10,309	3,792	6,517
46	165,217	80,548	84,669	96	4,973	1,975	2,998
47	144,972	70,983	73,989	97	2,951	1,232	1,719
48	184,120	88,514	95,606	98	4,910	1,751	3,159
49	110,694	53,659	57,035				

APPENDIX- B

Reported and Smoothed Male population for Ghana-2010

MALE	Reported	SMOOTHED POPULATION				
Total		CarrierFarrag	K.Newton	Arriaga	Unite Nations	Strong
0-79	**11,901,797**			**11,901,797**		**11,901,797**
10-69	**8,341,717**	**8,341,717**	**8,341,717**	**8,341,717**	**8,347,551**	**8,341,717**
0-4	1,731,787			1,718,477		1,737,100
5-9	1,589,632			1,602,942		1,584,319
10-14	1,477,525	1,478,835	1,474,161	1,478,576	1,471,607	1,430,577
15-19	1,311,112	1,309,802	1,314,476	1,310,061	1,305,705	1,272,023
20-24	1,100,727	1,103,844	1,104,568	1,101,072	1,109,797	1,105,250
25-29	943,213	940,096	939,372	942,868	938,023	955,440
30-34	790,301	796,610	797,181	794,360	794,349	803,180
35-39	676,768	670,459	669,888	672,709	676,449	679,601
40-44	572,620	564,489	563,665	562,227	566,267	564,366
45-49	452,975	461,106	461,930	463,368	466,455	465,892
50-54	394,600	368,723	367,985	366,266	374,535	370,190
55-59	258,582	284,459	285,197	286,916	280,200	295,481
60-64	227,050	204,388	207,555	204,112	206,606	224,362
65-69	136,244	158,906	155,739	159,182	157,560	175,356
70-74	149,512			128,024		135,092
75-79	89,149			110,637		103,569
80+	123,048					

Source: computed using PAS AGESMTH

APPENDIX-C

Reported and Smoothed Female population for Ghana-2010

FEMALE	Reported	SMOOTHED POPULATION				
Totals	REPORTED	Carrier Farrag	K-King Newton	Arriaga	United Nations	Strong
0-79	**12,440,648**			**12,440,648**		**12,440,648**
10-69	**8,909087**	**89,909,087**	**8,909,087**	**8,909,087**		**8,909,087**
0-4	**1,673,619**			**1,668,739**		**1,667,362**
5-9	**1,539,320**			**1,544,200**		**1,545,577**
10-14	**1,438,515**	**1,423,665**	**1,423,901**	**1,422,488**	**1,427,597**	**1,423,654**
15-19	**1,298,877**	**1,313,727**	**1,313,491**	**1,314,904**	**1,311,729**	**1,301,046**
20-24	**1,222,764**	**1,239,931**	**1,233,847**	**1,239,863**	**1,220,232**	**1,185,188**
25-29	**1,106,898**	**1,089,731**	**1,095,815**	**1,089,799**	**1,091,910**	**1,047,979**
30-34	**888,508**	**893,049**	**893,497**	**890,117**	**903,420**	**896,427**
35-39	**744,635**	**740,094**	**739,646**	**743,026**	**741,455**	**759,258**
40-44	**613,730**	**607,043**	**607,522**	**604,625**	**608,083**	**616,395**
45-49	**485,123**	**491,810**	**491,331**	**494,228**	**503,150**	**505,018**
50-54	**438,498**	**395,321**	**395,082**	**393,039**	**407,712**	**399,062**
55-59	**265,113**	**308,290**	**308,529**	**310,572**	**297,348**	**321,226**
60-64	**248,799**	**223,271**	**227,275**	**222,913**	**221,165**	**249,286**
65-69	**157,627**	**183,155**	**179,151**	**183,513**	**187,301**	**204,547**
70-74	**201,818**			**161,562**		**170,744**
75-79	**116,804**			**157,060**		**147,878**
80+	**193,330**					

Source: computed using PAS AGESMTH

APPENDIX-D

Reported and Smoothed Age Ratio for Ghana-2010

Age	Reported	SMOOTHED				
		Carrier Farrag	K.-King Newton	Arriaga	United Nations	Strong
0-4	103.5			103.0		104.2
5-9	103.3			103.8		102.5
10-14	102.7	103.9	103.5	103.9	103.1	100.5
15-19	100.9	99.7	100.1	99.6	99.5	97.8
20-24	90.0	89.0	89.5	88.8	90.9	93.3
25-29	85.2	86.3	85.7	86.5	85.9	91.2
30-34	88.9	89.2	89.2	89.2	87.9	89.6
35-39	90.9	90.6	90.6	90.5	91.2	89.5
40-44	93.3	93.0	92.8	93.0	93.1	91.6
45-49	93.4	93.8	94.0	93.8	92.7	92.3
50-54	90.0	93.3	93.1	93.2	91.9	92.8
55-59	97.5	92.3	92.4	92.4	94.2	92.0
60-64	91.3	91.5	91.3	91.6	93.4	90.0
65-69	86.4	86.8	86.9	86.7	84.1	85.7
70-74	74.1			79.2		79.1
75-79	76.3			70.4		70.0
80+	63.6					

Source: Computed using PAS AGESMTH

APPENDIX E

E. Age Ratios of the Reported and Smoothed Populations

Smoothed

Sex and age	Reported	Carrier Farrag	Karup King	Arriaga	United Nations	Strong
MALE						
5-9	99.1			100.3		100.0
10-14	101.9			101.5		100.2
15-19	101.7	101.4	101.9	101.6	101.2	100.3
20-24	97.7	98.1	98.0	97.7	98.9	99.2
25-29	99.8	98.9	98.8	99.5	98.5	100.1
30-34	97.6	98.9	99.1	98.3	98.4	98.2
35-39	99.3	98.5	98.5	99.2	99.4	99.4
40-44	101.4	99.8	99.6	99.0	99.1	98.5
45-49	93.7	98.8	99.2	99.8	99.2	99.7
50-54	110.9	98.9	98.5	97.6	100.3	97.2
55-59	83.2	99.3	99.1	100.6	96.4	99.4
60-64	115.0	92.2	94.1	91.5	94.4	95.3
65-69	72.4			95.9		97.6
70-74	132.7			94.9		96.9
FEMALE						
5-9	98.9			99.9		100.0
10-14	101.4			99.5		100.0
15-19	97.6	98.6	98.8	98.8	99.1	99.7
20-24	101.7	103.2	102.4	103.1	101.5	100.9
25-29	104.9	102.2	103.0	102.3	102.8	100.7
30-34	96.0	97.6	97.4	97.1	98.6	99.2
35-39	99.1	98.7	98.6	99.4	98.1	100.4
40-44	99.8	98.6	98.7	97.7	97.7	97.5
45-49	92.2	98.1	98.0	99.1	99.1	99.5
50-54	116.9	98.8	98.8	97.7	101.9	96.6
55-59	77.1	99.7	99.1	100.8	94.6	99.1
60-64	117.7	90.9	93.2	90.2	91.3	94.8
65-69	70.0			95.5		97.4
70-74	147.1			94.9		96.9

APPENDIX F

1.Female 2010

Terminal digit	Population 10 - 89	Ages 10-89 coefficient	Product 1	Population 20 - 89	Ages 20-89 coefficient	Product 2	Blended sum	Percentage distribution	Deviation from 10
0	1732823	1	1732823	1374109	9	12366981	14099804	17.4	7.4
1	781694	2	1563388	533194	8	4265552	5828940	7.2	-2.8
2	1006247	3	3018741	709595	7	4967165	7985906	9.9	-0.1
3	825801	4	3303204	556842	6	3341052	6644256	8.2	-1.8
4	802794	5	4013970	537104	5	2685520	6699490	8.3	-1.7
5	1255775	6	7534650	957940	4	3831760	11366410	14.1	4.1
6	780397	7	5462779	531745	3	1595235	7058014	8.7	-1.3
7	738847	8	5910776	503289	2	1006578	6917354	8.6	-1.4
8	878087	9	7902783	579394	1	579394	8482177	10.5	0.5
9	572104	10	5721040	353965	0	0	5721040	7.1	-2.9
TOTAL							80803391	100	

2.Males-2010

Terminal digit	Population 10 - 89	Ages 10-89 coefficient	Product 1	Population 20 - 89	Ages 20-89 coefficient	Product 2	Blended sum	Percentage distribution	Deviation from 10
0	1518046	1	1518046	1145150	9	10306350	11824396	16.1	6.1
1	777312	2	1554624	519263	8	4154104	5708728	7.8	-2.2
2	949889	3	2849667	638745	7	4471215	7320882	10	0
3	772255	4	3089020	502858	6	3017148	6106168	8.3	-1.7
4	757190	5	3785950	491151	5	2455755	6241705	8.5	-1.5
5	1120363	6	6722178	812861	4	3251444	9973622	13.6	3.6
6	729704	7	5107928	482233	3	1446699	6554627	8.9	-1.1
7	695077	8	5560616	455969	2	911938	6472554	8.8	-1.2
8	816669	9	7350021	515436	1	515436	7865457	10.7	0.7
9	539167	10	5391670	323369	0	0	5391670	7.3	-2.7
TOTAL							73459809	100	

3.
Total
Population
2010

Terminal digit	**Population 10 - 89**	**Ages 10-89 coefficient**	**Product 1**	**Population 20 - 89**	**Ages 20-89 coefficient**	**Product 2**	**Blended sum**	**Percentage distribution**	**Deviation from 10**
0	3250869	1	3250869	2519259	9	22673331	25924200	16.8	6.8
1	1559006	2	3118012	1052457	8	8419656	11537668	7.5	-2.5
2	1956136	3	5868408	1348340	7	9438380	15306788	9.9	-0.1
3	1598056	4	6392224	1059700	6	6358200	12750424	8.3	-1.7
4	1559984	5	7799920	1028255	5	5141275	12941195	8.4	-1.6
5	2376138	6	14256828	1770801	4	7083204	21340032	13.8	3.8
6	1510101	7	10570707	1013978	3	3041934	13612641	8.8	-1.2
7	1433924	8	11471392	959258	2	1918516	13389908	8.7	-1.3
8	1694756	9	15252804	1094830	1	1094830	16347634	10.6	0.6
9	1111271	10	11112710	677334	0	0	11112710	7.2	-2.8
TOTAL							154263200	100	

URBAN 2010

Terminal digit	Population 10 - 89	Ages 10-89 coefficient	Product 1	Population 20 - 89	Ages 20-89 coefficient	Product 2	Blended sum	Percentage distribution	Deviation from 10
0	1504154	1	1504154	1176709	9	10590381	12094535	14.5	4.5
1	876036	2	1752072	627292	8	5018336	6770408	8.1	-1.9
2	1041060	3	3123180	761108	7	5327756	8450936	10.2	0.2
3	900748	4	3602992	633390	6	3800340	7403332	8.9	-1.1
4	882518	5	4412590	614788	5	3073940	7486530	9	-1
5	1166678	6	7000068	872095	4	3488380	10488448	12.6	2.6
6	840903	7	5886321	583473	3	1750419	7636740	9.2	-0.8
7	812742	8	6501936	555722	2	1111444	7613380	9.1	-0.9
8	921373	9	8292357	609976	1	609976	8902333	10.7	0.7
9	636427	10	6364270	392733	0	0	6364270	7.6	-2.4
TOTAL							83210912	99.9	

RURAL 2010

Terminal digit	Population 10 - 89	Ages 10-89 coefficient	Product 1	Population 20 - 89	Ages 20-89 coefficient	Product 2	Blended sum	Percentage distribution	Deviation from 10
0	1746715	1	1746715	1342550	9	12082950	13829665	19.5	9.5
1	682970	2	1365940	425165	8	3401320	4767260	6.7	-3.3
2	915076	3	2745228	587232	7	4110624	6855852	9.6	-0.4
3	697308	4	2789232	426310	6	2557860	5347092	7.5	-2.5
4	677466	5	3387330	413467	5	2067335	5454665	7.7	-2.3
5	1209460	6	7256760	898706	4	3594824	10851584	15.3	5.3
6	669198	7	4684386	430505	3	1291515	5975901	8.4	-1.6
7	621182	8	4969456	403536	2	807072	5776528	8.1	-1.9
8	773383	9	6960447	484854	1	484854	7445301	10.5	0.5
9	474844	10	4748440	284601	0	0	4748440	6.7	-3.3
TOTAL							71052288	100	