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Data Reliability: Comparison between Census and Health and Demographic Surveillance System (HDSS) Outputs for Kassena-Nankana East and West Districts, Ghana

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Abstract

Considering the importance of reliable and accurate demographic data for development planning and the errors often associated with census data in Africa, this paper examines the level of consistency of reporting between the 2010 Ghana Population Census and the Health and Demographic Surveillance System (HDSS) for Kasena-Nankana East Municipal and Kassena-Nankana West district in the Republic of Ghana. We apply data evaluation techniques to assess data quality and adopt Test of Proportions to examine differences between the two data systems. The results show some level of consistency between the Census and HDSS data relative to age-sex distribution, crude death rate and mortality pattern. However, the HDSS data suggest relatively better reporting than the Census. We conclude that the large differences observed in some indicators need to be interrogated further to identify their sources so as to allow for improvement in quality of subsequent waves of data collection.

Keywords

HDSS, census, reliability, Kassena-Nankana, Ghana

Introduction

Accurate, reliable and timely demographic data are very useful as they provide essential bases to inform public policies and programme implementation. Governments' efforts to improve the well-being of people should rely on accurate, complete and timely data on key demographic indicators. Many developing countries, however, often do not have such data, (Mahapatra et al. 2007; Mathers et al. 2005; Soto et al. 2013), leading to poor decision-making and less than effective interventions. The paucity of data challenge has often been due to a lack of well-established vital registration systems in many countries (United Nations 2010). Even where data are available, they are usually not critically interrogated to ascertain their level of accuracy and reliability and, therefore, do not provide enough evidence-based information to inform programming activities for development.

Several sources of demographic data exist in Africa, with the common ones being censuses, demographic and health surveys as well as vital registration systems. Unlike the developed countries, however, many African countries do not have well established vital registration systems, and where these are available they are incomplete and not suitable for any meaningful analysis (United Nations 2012; Joubert et al 2012). As a result, countries have had to depend on either censuses that are conducted decennially or demographic and health surveys that are conducted every five years or both for their analysis. These sources have drawbacks, which include the problem of recall bias that sometimes results in the underestimation of some vital rates (Byass et al 2007).

An important system of demographic data collection in developing countries that is now gaining popularity is health and demographic surveillance systems (HDSS). A number of these HDSS sites have been established across Africa and Asia. The International Network of field sites with continuous Demographic Evaluation of Populations and their Health (INDEPTH-Network) is a body that facilitates cross-sites activities of HDSS sites with the aim of improving demographic data quality of respective sites (INDEPTH-Network 2015). HDSS typically involve the monitoring of populations within a well-defined geographical area, with the collection of core demographic and health data as well as some socio-economic data (see www.indepth-network.org). Since July of 1992, the Navrongo Health Research Centre (NHRC) has been operating a HDSS site.

Censuses and other demographic data sources are often subjected to various types of errors (Moultrie et al 2013; Cleland 1996), which include coverage and content errors. While coverage errors emanate from undercount or overcount of the population, content errors result from misreporting by respondents and/or inputting wrong information about the individual or population characteristics as a whole. These errors go a long way to present erroneous characteristics of the population and thus make them unreliable. To identify and correct these errors, several techniques have been designed and adopted for the evaluation and validation of demographic data. These include i) comparison of observed data with a theoretically expected configuration, ii) comparison of expected data in one country with those observed elsewhere, iii) comparison with similar data obtained for non-demographic purpose, iv) balancing equation of directly interrelated data, and v) direct checks, such as Post Enumeration Survey (United Nations 1995; Moultrie et al 2013).

The Republic of Ghana conducted a national population and housing census in 2010 with a reference date of 26 September. The census report characterized the demographic and social profile of each district of the country, including the Kassena-Nankana East Municipal and Kassena-Nankana West district where the Navrongo HDSS operates. The two data sources (Census and HDSS) offer the opportunity to validate the accuracy and reliability of each data.

The objective of this paper is to examine the two independent data sources for the purpose of comparing their respective outputs relative to some key demographic and health indicators to find areas of convergence and divergence in terms of data accuracy. Even though different methods are used, it is expected that there should not be substantial variations between the two sources of data collected from the same geographical areas.

The usefulness of this study is twofold. First, data users have often expressed some skepticism about the quality and reliability of the data they are presented with. This comes about when locally produced data and indicators are at variance with those produced by international institutions, such as the United Nations. Studies of this kind, where data from two locally and independent sources are compared provide data users with the opportunity to make a better judgment of the reliability of the indicators produced from the analysis of data from these sources. Usually because these data are not interrogated, virtually nothing is known about any potential biases associated with indicators that are expected to inform possible programme interventions or policy decisions. Second, comparing data from two sources illuminates similarities and variations in their outputs, allowing users to assess the level of consistency between the two sources. Where there are inconsistencies, sources may be identified that can serve as a guide for subsequent waves of data collection to ensure relatively higher quality data for analysis, which can better inform policy and program decision-making.

Methods

Data source

Data for this analysis come from two independent sources: 1) the 2010 Ghana Population and Housing Census and 2) the Health and Demographic Surveillance System (HDSS) of the Navrongo Health Research Centre. In 2010, Ghana conducted a population and housing census (with 26 September as the reference date). The Ghana Statistical Service charged with conducting national censuses in the country. Under the census data collection process, fieldworkers are sent out to enumerate all household members who are present in the household at the time of the census (26 September).

Details of the census data collection processes can be found elsewhere (Ghana Statistical Services 2013). Adjustment of the age data was done using smoothing techniques, such as Arriaga and Strong (Ghana Statistical Services 2013). The difference between the original and smoothed data, however, was minimal.

Under the HDSS, fieldworkers visit all households every four months to collect and update the health and socio-demographic information of the people and their households. Demographic data collected include pregnancies, births, deaths, migrations and marriages. Annual updates are also done on the educational status of all individuals 6 years and above. To ascertain causes of death of the population, verbal autopsies are conducted on all deaths that occur to individuals who are registered members of the HDSS (Oduro et al 2012).

Several strategies are put in place to ensure that data are of high quality. These include regular visits to check on data collectors and re-interviews at selected households. On the latter point, 5 percent of all the households (numbering over 30,000) are generated randomly for re-interview by field supervisors. Data from the re-interviews are compared with the work of the fieldworkers, and where discrepancies are found they are resolved. Before completed, questionnaires are sent for data entry, and a rigorous review is done by supervisors to ensure there are no blanks, inconsistencies or errors. Where any error is detected and cannot be resolved immediately, it is taken back to the field for resolution. All these checks tend to place HDSS data at a relatively high level in terms of quality and reliability. The comparison of the two sources of data is undertaken based on the assumption that the HDSS data are relatively more accurate and, therefore, can serve as the basis for assessing the level of accuracy of the census data.

Method of analysis

As noted by Moultrie et al (2013), it is usually not possible to consider all available information for the appraisal of demographic data. As a result, even though the HDSS and the Census collect a broad spectrum of socio-demographic data, this analysis is limited to comparing some selected demographic indices of the two systems. The main indicators for comparison in this analysis are population size, age-sex distribution as well as mortality level and pattern of the study area. Population pyramids, line and bar graphs are used for the comparison. The analysis also compares accuracy of age reporting between the HDSS and the Census. Myer's Index is employed to assess the quality of age reporting between the two systems. Test of proportion is also used to check for any significant difference between the broad age categories of the two systems. The justification for the selection of these indices for the data quality assessment is the fact that they form mostly the basis (denominators) from which most demographic rates are calculated. Since any error in these indices could affect any indicator calculated from them, there is the need to interrogate these basic indices to ensure a high level of reliability and validity (Ghana Statistical Services, 2013).

The study area

The study area is the HDSS operational area, which comprises the Kassena-Nankana East (KNE) and Kassena-Nankana West (KNW) districts in the Upper East Region of Ghana. The two districts constituted one district until February 2008 when it was divided into two. The study area (KNE & KNW) is located about 30 and 850 kilometers north of the regional capital of Bolgatanga and the national capital of Accra, respectively. It covers an area of 1,675 square kilometers along the Ghana-Burkina Faso border. Located in the Guinea Savannah belt, the ecology is typically Sahelian (hot and dry).

In terms of the economy, subsistence agriculture is the primary activity in both districts, which is complemented by some retail trading. About 90 percent of households are engaged in subsistence agriculture, which depends largely on rainfall, and thus limits food cultivation to a single growing season. However, there is an irrigation dam and a few dugout wells that supply water for dry season farming. The districts occasionally experience severe drought and flooding resulting in poor harvest. This situation has culminated in seasonal out-migration of the population from the districts to other parts of the country as well as to neighboring Burkina Faso in search of jobs.

Results

Population characteristics

We first compare the population characteristics as enumerated by the Census and the HDSS. The population of the study area (Navrongo) as recorded by the Census was 180,611, while that of the HDSS was 153,766. The sex ratio was 96.1 and 91.6 as recorded by the Census and the HDSS respectively. The census and the HDSS show that 22.2 percent of the target population resides in an urban area. With regards to the total population, the Census recorded 17 percent more people than the HDSS and this needs some explanation and interrogation. The difference could be due to the different methods applied (de-jure and de-facto) and the respondents' understanding of household membership during the interviews. For the HDSS, strict household membership is applied. For instance, household membership in the HDSS refers to those who are resident and so any member who stays (moves) away from a household for at least three months ceases to be a household member. Thus, during each routine visit any member who is deemed to have been wrongly included in the household count in a previous round is removed. For the Census, however, respondents have the tendency of including non-resident household members and there is no opportunity for any means of verification to exclude such people. This is because, as noted by Hosegood et al (2005), household membership in some settings is not tied to residency. This is particularly so if non-resident members still have ties with their places of origin. In these instances, the Census population may include non-resident members who the HDSS omits, thus inflating their counts.

With respect to the difference in the sex ratio, the plausible explanation is that the non-resident members that are excluded by the HDSS but included by the Census tend to be males, who are out-migrants. Men who want to be identified with their home towns are more likely to return home during the Census period to be counted. As a result, the Census will have more males compared to the HDSS, hence the higher sex ratio observed in the Census population compared with the HDSS.

We next looked at the age-sex structure of the population as produced by the two systems. Even though the use of a population pyramid is not recommended as a good tool for demographic data quality assessment, it provides a quick view of the population structure and the changes therein over time (Moultrie et al 2013). Using population pyramids from the two systems (Figure 1), it is observed that the structures look similar with a shrinking of the youngest age group (bottom bar) indicating a decline in fertility in the study area. However, some differences exist between the two pyramids as the pyramid for the HDSS shows a bulge in the female population of age 40-44 and 50-54 years, while a bulge is observed in the census pyramid for females aged between 60-64 and 70-74 years. Similar but smaller bulges are also observed in these age groups for the males in both pyramids. There seems to be a shift of 20 years upwards in these bulges for the census population.

Figure 1. Comparison of population pyramids

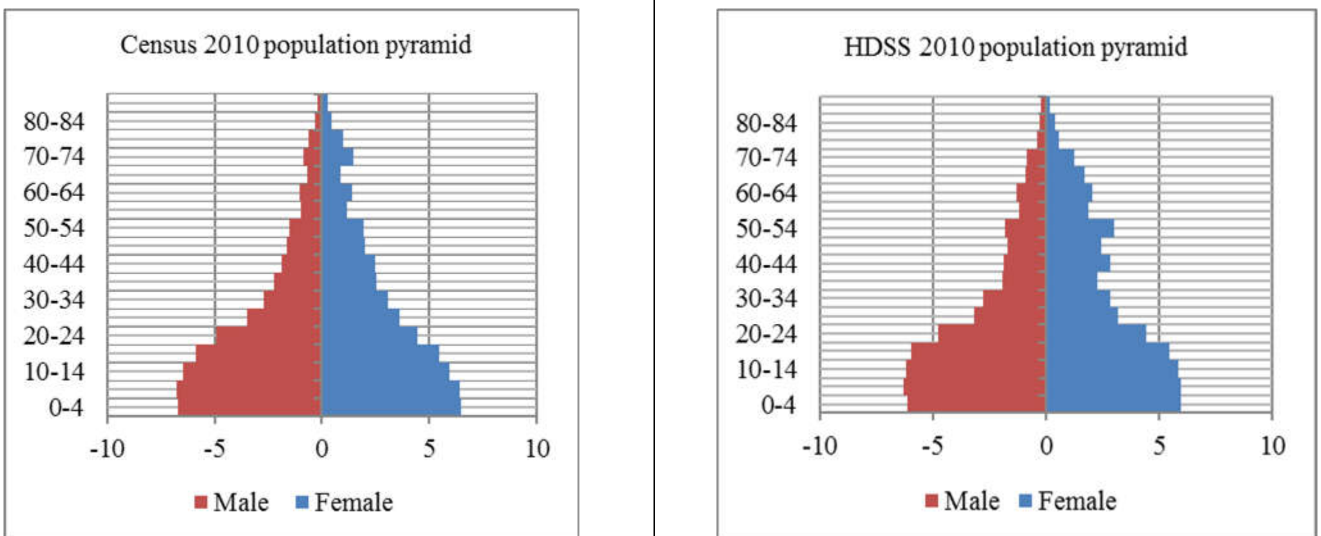


Figure 2 shows a graph of the age distribution of the population reported in the Census and the HDSS,

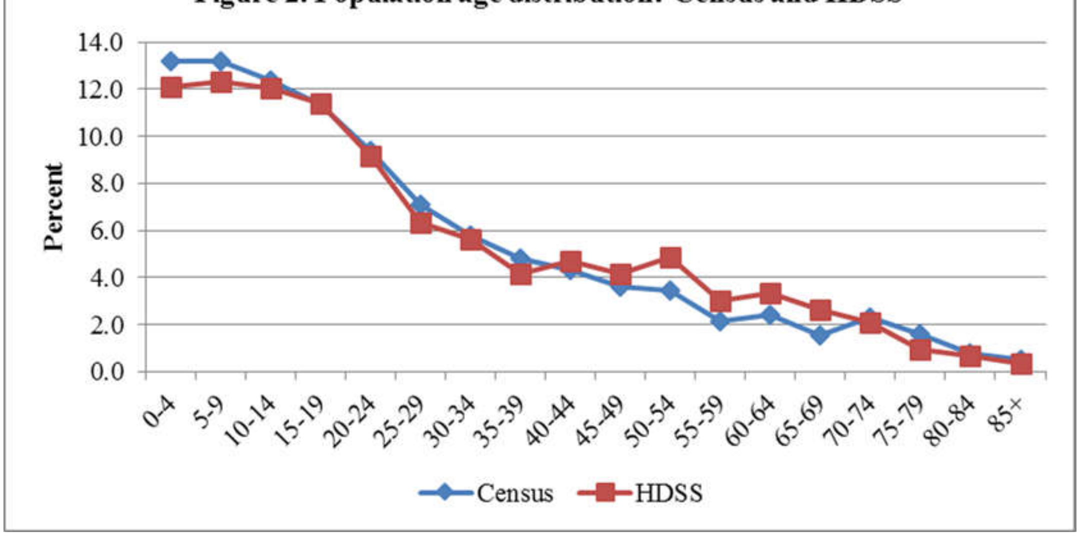
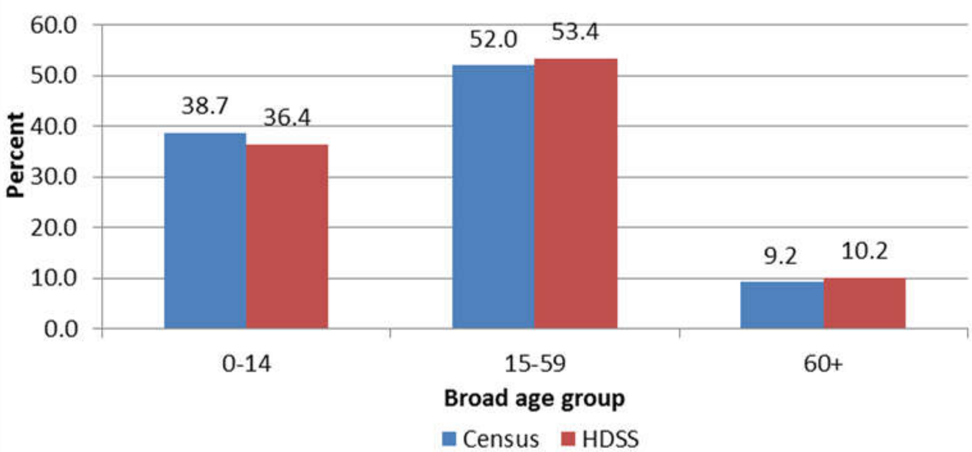


Figure 2. Population age distribution: Census and HDSS

which shows a similar pattern with the census having proportionately more children than the HDSS up to age 9 years. The population distribution for the two systems matches up to age 44 years and then the HDSS proportions become slightly higher than that in the census. The distribution essentially becomes the same at age 70 years and over, except at age 75-79 where the census proportion becomes slightly higher than that of the HDSS.

We next compare the broad age categories between the Census and the HDSS. Three broad age groups are generated: 0-14, 15-59 and 60+ years. Figure 3 shows a graph of the broad age categorization of the population as recorded by the census and the HDSS, where the proportion of those in the age group 0-14 years in the Census data is higher than that of the HDSS. In contrast, the HDSS has a higher proportion of those aged 15-59 and 60+ than the Census.

Figure 3. Broad age categories: Census and HDSS



While the graphical presentation seems to show some level of closeness in the proportional distribution of the broad age categories between the two systems, statistical presentation using the test of proportion shows significant differences between the Census and the HDSS in all age groups. For instance, as shown in Table 1, the proportion of the population age 0-14 years as recorded by the Census is significantly

Table 1. Test of proportions of means of broad age categorization between Census and HDSS

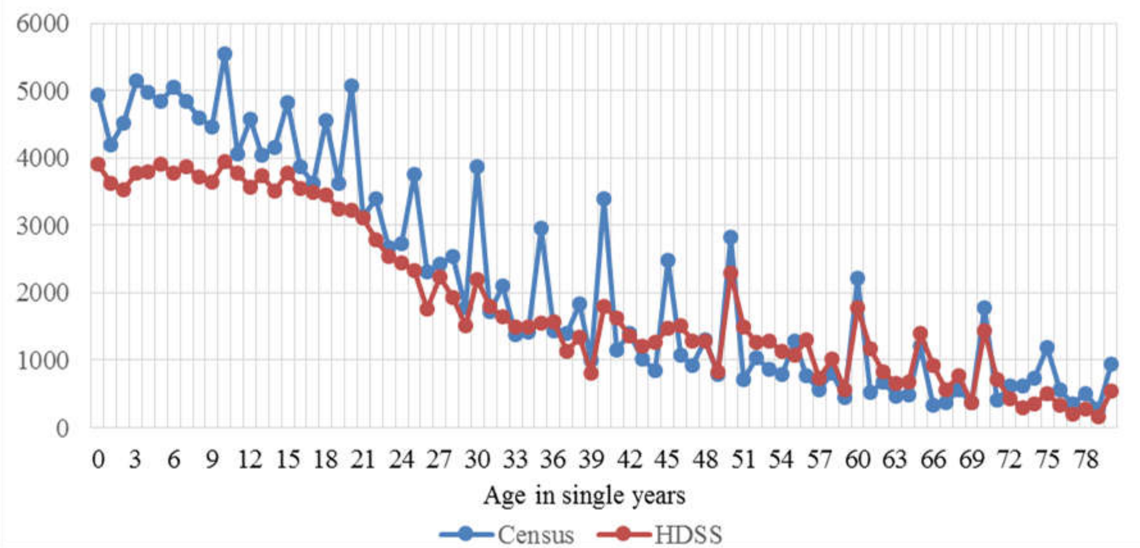
Age group (years)	Census population mean	HDSS population mean	Z-score	P-value
0-14	0.387	0.364	13.7	<0.0001
15-59	0.521	0.534	-8.1	<0.0001
60+	0.092	0.102	-7.8	<0.0001

higher than that of the HDSS. On the other hand, the proportions of the population age 15-59 and 60 years or more as recorded by the HDSS are significantly higher than those in the Census.

Age misreporting

The important variables of age and sex have received considerable attention in demographic analyses (Bogue 1969, as cited in Randall and Coast 2016). The indispensability of age in demographic analyses cannot be overemphasized as it has a major influence on socio-demographic outcomes, such as mortality, fertility, migration, education and marriage, among others (Mba 2014; Poston and Micklin 2006; Lerche 1983; Kpedekpo 1982). However, despite its importance, age is one of the most difficult variables to collect and analyze in terms of its accuracy and reliability (Ghana Statistical Service 2013). Age misreporting has been observed to occur in most censuses in Africa, often due to the inability of some respondents to provide their accurate age or date of birth, along with the age or date of birth of their household members. The problem of age misreporting has been found to be more pervasive in rural areas where the educational levels of the population are low (Borkotoky and Unisa 2014).

Figure 4. Age misreporting (digit preference): Census and HDSS



Preference for or avoidance of each of the terminal digits along the age spectrum provides us with the extent to which each terminal digit is preferred or avoided. In this analysis, we use the Myer's blended index to compare digit preference along the entire age spectrum as well as generate a composite index separately for the HDSS and the Census. The results of the composite index reveal general digit preference or avoidance in both systems. For instance, as shown in Table 1, the HDSS has a composite value of approximately 5.6. This means that for the HDSS about 5.6 percent of the population reported their ages with an incorrect terminal digit and, therefore, an inaccurate age. Along the entire age spectrum, the results reveal that there is over-selection of ages ending with digits "0", with the percentage digit preference being 13.8. There is also some preference for ages ending with digit "1". The most avoided terminal digit for the HDSS is "9".

Table 2. Myer's blended index for HDSS

	10-89		20-89						
Terminal digits	Sum	Coefficient	Product	Sum	Coefficient	Product	Blended sum	Distribution percent	Deviation from 10
0	17234	1	17234	13292	9	119628	136862	13.78	3.78
1	13942	2	27884	10172	8	81376	109260	11.00	1.00
2	11980	3	35940	8420	7	58940	94880	9.55	-0.45
3	11310	4	45240	7564	6	45384	90624	9.13	-0.87
4	10966	5	54830	7449	5	37245	92075	9.27	-0.73
5	12217	6	73302	8440	4	33760	107062	10.78	0.78
6	11016	7	77112	7459	3	22377	99489	10.02	0.02
7	9700	8	77600	6202	2	12404	90004	9.06	-0.94
8	10119	9	91071	6668	1	6668	97739	9.84	-0.16
9	7503	10	75030	4262	0	0	75030	7.56	-2.44
Total							993025		11.17÷2=5.6

On the other hand, as shown in Table 3, the overall digit preference index for the Census is approximately 12.7 percent. This means that about 13 percent of the Census population in the study area reported their age with an incorrect terminal digit. Along the entire age spectrum, there is high preference for ages

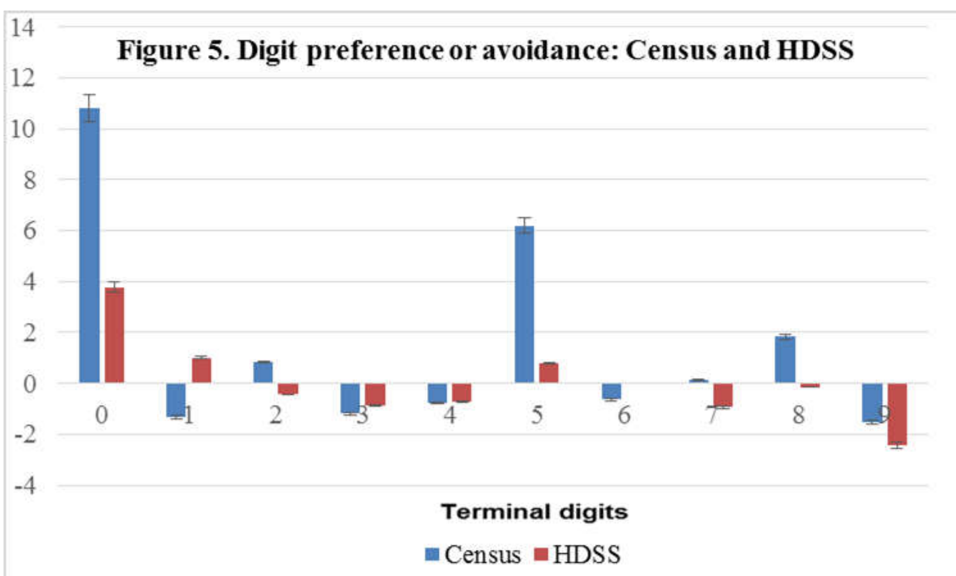
Table 3. Myer's blended index for Census

	Ages 10-89		Ages 20-89						
Terminal digits	Sum	Coefficient	Product	Sum	Coefficient	Product	Blended sum	Distribution percent	Deviation from 10
0	25643	1	25643	20108	9	180972	206615	20.81	10.81
1	11862	2	23724	7802	8	62416	86140	8.67	-1.33
2	13970	3	41910	9393	7	65751	107661	10.84	0.84
3	11168	4	44672	7130	6	42780	87452	8.81	-1.19
4	11232	5	56160	7084	5	35420	91580	9.22	-0.78
5	18014	6	108084	13201	4	52804	160888	16.20	6.20
6	10453	7	73171	6573	3	19719	92890	9.35	-0.65
7	10791	8	86328	7173	2	14346	100674	10.14	0.14
8	12204	9	109836	7648	1	7648	117484	11.83	1.83
9	8404	10	84040	4773	0	0	84040	8.46	-1.54
Total							1135424		25.30÷2= 12.7

ending with digits "0" and "5", with the respective percentages being 20.8 and 16.2. The most avoided terminal digits are "9" and "1". Comparing these with the results from the HDSS indicates a better age reporting by the latter (HDSS).

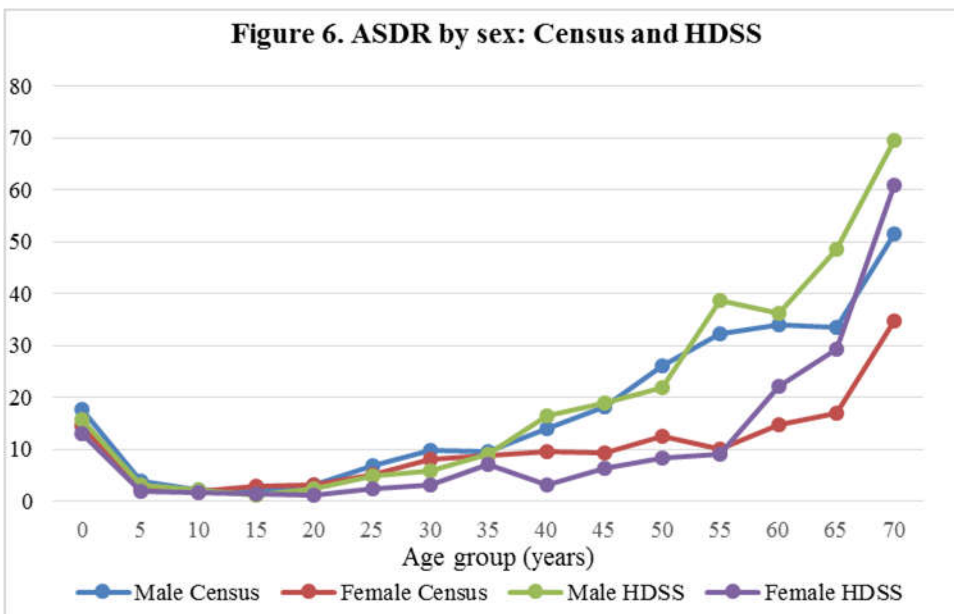
Figure 5 shows the graph (summary) of digit preference for the HDSS and Census. High level of preference for ages ending in zero and five is exhibited in both the Census and HDSS. However, as indicated earlier, the levels are higher for the Census compared to the HDSS for most of the terminal digits. Using a similar method (i.e. Myer's blended index), the overall index for Ghana as estimated by the Census was 22.5, with rural areas being 30.4 and urban having 16.0 (Ghana Statistical Services 2013). Navrongo is largely rural. An overall index of 12.7 from the Census report compared with an index of 16 for rural Ghana means that Navrongo has a better age reporting than the average rural population.

The reasons for differences in the quality of age reporting between the Census and the HDSS are not far-fetched. As it is with all HDSS data, repeated visits to households offer some opportunity for the correction of any information that is found to be incorrect. Another plausible reason is the experience acquired by the HDSS fieldworkers over time in the collection of information, which includes proper assessment of the ages of respondents and their household members. Another factor is that the Navrongo HDSS has been operating for about 25 years and, hence some of the ages were recorded at birth and so will be more accurate. Because the Navrongo HDSS has been operational for a long period of time, the researchers are, in most cases, trusted by the people, leading to the divulgence of more accurate information.



Mortality

Total deaths recorded within one year up to the reference date were 1,783 and 1,546, giving crude death rates (CDR) of 9.9 and 10.0 per 1000 for the Census and HDSS respectively. Figure 6 shows the age-specific death rates (ASDR) by sex for the Census and HDSS. The expected pattern is observed for the two systems, with some small variations. There is no observed significant difference in the pattern up to age 39 years for both sexes and up to age 54 years for males. A slight difference is, however, observed at age 55-59, which levels up at age 60-64 years, and then significant differences are observed thereafter. For females, there is a slight difference in the pattern at age 40-44, and then levels up to 59 and subsequently deviates thereafter. In particular, it is observed that at older ages (50+ years for males and 60+ years for females) the HDSS recorded higher ASDR than the Census. However, a test of proportion method revealed a significant difference in the rates between the two systems only at age 65 years and beyond. This means that proportionately more deaths were recorded at those ages by the HDSS than the Census. The possible reason for the under-reporting by the Census could be due to recall bias since respondents provided information retrospectively, covering a period of one year. As a result, respondents could have entirely forgotten about the death or misjudged the timing to have occurred outside the reference period (one year period). HDSS fieldworkers do, however, visit every household three times a year, making it likely that respondents had a better recall of all events that may have occurred within the four month interval. They are, therefore, more likely to report all deaths that have occurred within the period.



Discussion

The results show some level of consistency and comparability between the Census data and the HDSS, albeit some other significant differences. In comparison to the Census, the HDSS tends to undercount the overall population. This difference could come from the fact that different methods were used in the data collection. Whereas the Census used the de-facto method, the HDSS used the de-jure method. As it happens in some places, people prefer to be counted in their home districts and may move to their home towns during censuses in order to be counted there instead of their usual places of residence. In these situations, censuses will include non-resident members, whereas the strict inclusion criteria of the HDSS will not count such people. Another problem is the inability of the Census to measure migration prevalence accurately, especially where migrants still maintain ties with their people at place of origin (Lurie et al 1997). Individual residency status could be misconstrued, as respondents may view migrants' destination as temporary and erroneously count them as members, even though those members are mostly away. Also, with repeated visits by the HDSS, non-resident household members are removed from the household records if it is noticed that such members are migrants and are living elsewhere. The Census, on the other hand, has no such opportunity to exclude non-resident members from their registers. As a result, the Census population will tend to be more than that of the HDSS population in view of some non-resident household members sometimes purposefully returning home to be counted during time of the Census, as was earlier explained. In Ghana, in some cases, some chiefs would call on their subjects to come home to be enumerated during national censuses in the hope that with a higher recorded population it would serve as a good basis for negotiating for amenities. This could lead to an overcount of the census population compared to the de-jure (usual place of residence) method adopted by the HDSS.

Age misreporting has been a major phenomenon that has contributed to errors in various demographic and socio-economic analyses (Agrawal and Khanduja 2015). This phenomenon leads to age heaping, resulting from digit preference. The comparison between the graph for the Census and HDSS single age data shows that there is a high level of age misreporting, leading to a greater digit preference for the Census than the HDSS. This can be explained by the fact that, due to the repeated visits of the HDSS, age misreporting errors are corrected over time. This is done by comparing ages of siblings during subsequent visits and drawing from the age of one to correct the wrong age. It can also be explained that the HDSS had some of the people registered at birth, particularly those below age 25 years, since the Navrongo HDSS has been in existence since then. Those who were born some few years before the establishment of the HDSS had their dates of birth/ages accurately established, leading to a smooth age distribution as observed for the HDSS up to age 25 years, with minimal peaks thereafter.

Mortality (deaths) is the simplest demographic event to comprehend compared to births and migration. It is thus expected that collecting mortality information using different systems should not yield any significant difference between the systems. However, the results of the analysis show that the 2010 Census recorded more deaths than the HDSS. This could be as a result of recall bias where respondents might have added deaths that occurred before the start of the reference period of September 2009. Also, some of the reported deaths could have occurred outside the household and the funeral brought home. On the other hand, the strict inclusion criteria employed in the HDSS excludes all deaths to individuals who have lived outside the study area more than three months before death. This difference in the data collection methodologies could result in the overcount of deaths for the Census compared with the HDSS.

It has to be realized that due to differences in operational definitions and concepts, differences between the two systems are inevitable, particularly when absolute numbers are used for comparison. As a result, the data have to be standardized in order to make a fair comparison. Using rates instead of absolute numbers gives a more comparative understanding of the various data sources. Even though there is a difference in the absolute number of registered deaths between the two systems, the CDR and the ASDR show a close association between the two data sources, except at the terminal ages where differences exist in the ASDR between the Census and HDSS. Using different demographic techniques, this analysis has revealed some similarities between the two systems. Some differences, however, have been revealed and possible factors responsible for these differences have been enumerated to include the differences in the methods of data collection adopted in the Census compared to the HDSS, with the latter offering more room for correction of reporting errors than the former.

Conclusion

Even though the results of the analysis have shown some consistency between the Census and HDSS, differences in some of the indicators are worthy of note. It is important to realize that the total population of any geographical area forms the basis (denominator) for the calculation of most, if not all relevant rates and indices. The results of this study have shown that the 2010 Population and Housing Census of Ghana recorded more people than the HDSS with reference to the Kasena-Nankana Municipal and Kasena-Nankana West district, which formed the basis for the analysis. Perhaps, it has to be noted that the observed differences could result from either Census overcount or HDSS undercount, which may require further investigation. Given that the two data collection systems are completely independent of each other and use different methods and concepts, it is expected that not all outputs from these datasets will be the same. However, when a large difference between population counts by different systems occurs, some serious interrogation becomes necessary. On the other hand, when outputs are comparable, it may be concluded that there is some level of accuracy in the responses provided by household members. We should, however, not lose sight of the fact that comparability of the reporting between the two sources of data used in this study could be due to consistency in the responses given by household members, which could be inaccurate by similar margins in either the Census or the HDSS and, therefore, not necessarily consistency in accurate reporting by respondents. Given the difficulty in determining the level of accuracy of the information provided by each system, we are confronted with the problem of determining which data output is trustworthy. This analysis is not, however, intended to rate one system more superior than the other as each has its strengths and weaknesses.

As mentioned elsewhere, there is no data collection activity or method that does not suffer from errors, either content or coverage or both. Efforts are always made to ensure that those errors are minimized. Doing internal consistency checks helps to identify and subsequently deal with some of these errors. Doing a comparative analysis to validate two demographic data collection methods that are different in many ways can give confidence to data users and show the level of quality and reliability. If there are marked variations in the results, measures can be put in place to identify the source of these discrepancies and find ways of addressing them in subsequent waves of data collection. It is recommended that institutions that are engaged in the collection of common data should collaborate to share their experiences, enabling researchers to ascertain the strengths and weaknesses of each system. Collaboration of this type will improve data quality and assure users of the usefulness of data collection activities.

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