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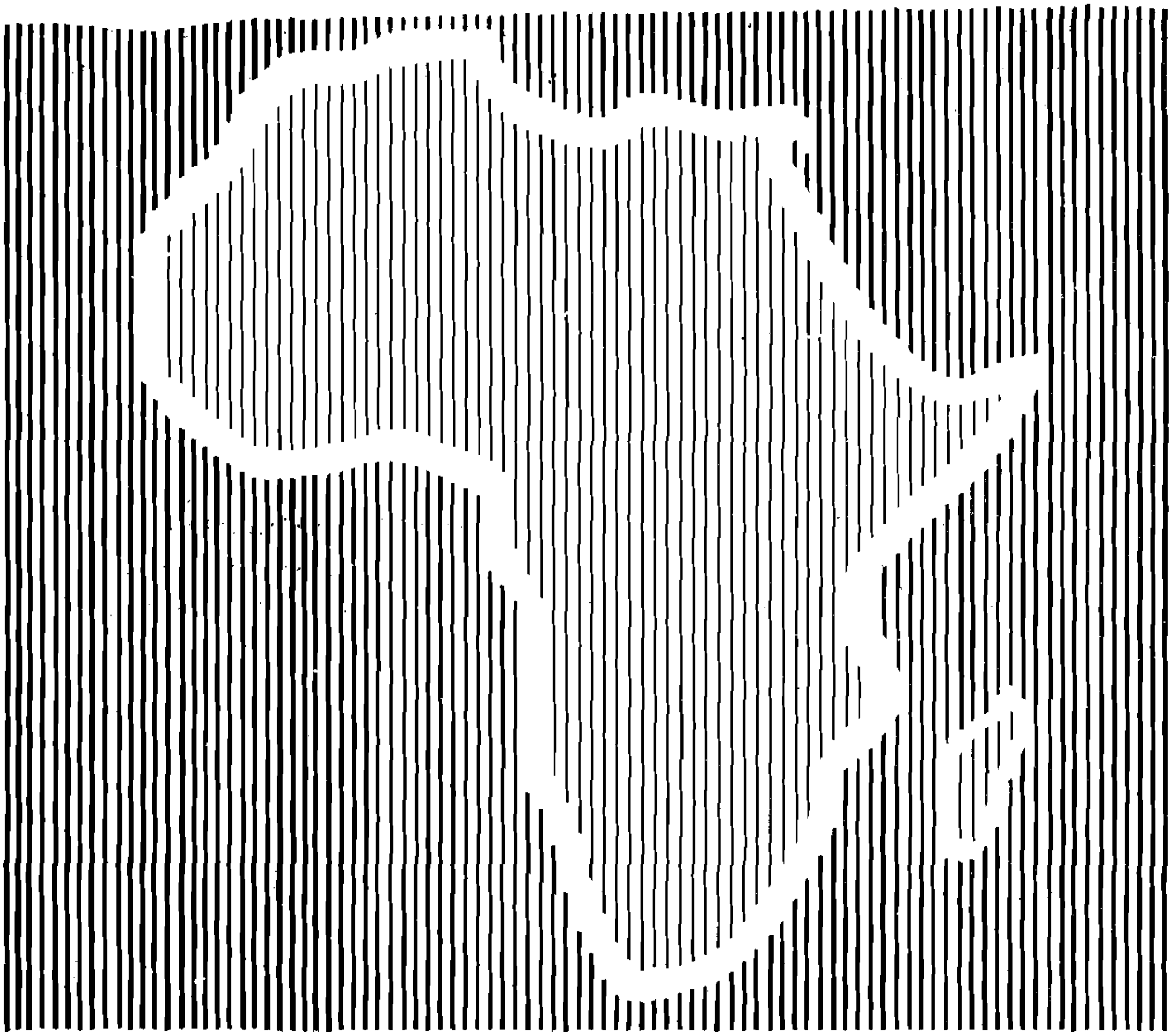

Bulletin d'information statistique pour l'Afrique

EDITORIAL NOTE

This issue of the Bulletin is devoted to a single subject - Coverage and Content Error Evaluation in African Censuses and Surveys. The papers were originally prepared to be presented to an expert working group on the topic in 1981. However due to financial constraints, the Division was unable to hold this working group. Given the importance of this topic, it was considered appropriate that the papers should be given wider dissemination. Thus the idea to publish them in this issue of the Bulletin.

In conformity with the practice adopted for the previous issues of this Bulletin, the papers in this issue have been given in their original language (English) with a short summary in ECA's other working language, French

NOTE DE LA REDACTION

Le présent numéro du Bulletin est consacré à un sujet unique : évaluation des erreurs de couverture et de contenu dans les enquêtes et les recensements africains. Les présentes études étaient initialement destinées à un groupe d'experts prévu sur la question en 1981. Toutefois, en raison de contraintes financières, la Division n'a pu réunir le groupe de travail en question. Etant donné l'importance du sujet, il a été jugé nécessaire d'assurer une diffusion plus large aux études; d'où l'idée de les publier dans le présent numéro du Bulletin.

Conformément à l'habitude prise pour les numéros antérieurs du Bulletin, les études ont été présentées dans la langue du texte initial et résumées dans une autre langue de travail de la CEA, à savoir le français.

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COVERAGE AND CONTENT ERROR EVALUATION - PRACTICES AND PROBLEMS IN AFRICAN CENSUSES, 1960-80

INTRODUCTION

That all statistical data collection systems, such as censuses and surveys are prone to errors is gradually becoming acknowledged by both producers and users of statistics. With particular reference to censuses, given the gigantic scale of their operations, involving large numbers of personnel - supervisors, enumerators, coders, statisticians, etc., - it is small wonder that their results are influenced by errors of various types. Errors usually enter the collected data because of flaws in the phases of the exercise: poor mapping work, poor questionnaire design, inadequate attention paid to training of interviewers etc.

For analytical purposes, we can divide the errors of a census in two: errors of coverage and errors of content. Coverage errors comprise those errors that affect the headcounts or counts of housing units. These errors take two forms - underenumeration, the more usual type, occurs when some persons or housing units that should be counted are missed. Overenumeration, on the other hand, occurs when a set of persons or housing units are enumerated more than once.

Content errors are errors related to the information on the characteristics of persons and housing units reported in the census.

An evaluation programme of a census attempts to estimate the magnitude of errors and sometimes to delineate their causes and patterns. The results will enable users of the statistics to decide, given their magnitude, whether they are suitable for use in a given circumstance. Moreover, the identification of causes of certain errors will help survey statisticians to institute remedial measures in future censuses or surveys.

This paper has the objective of reviewing the problems and practices of content and coverage error evaluation in African censuses, covering the period 1960 to 1980.

POST ENUMERATION SURVEY (PES) 1/

The post enumeration survey (PES) is one of the methods for directly evaluating the coverage of population censuses. The PES involves a duplication of the census enumeration in a sample of enumeration areas chosen on the basis of probability sampling. The objective of the exercise is to match information about persons enumerated or housing units listed in the census with those in the PES in order to estimate the magnitude of error of coverage and identify the causes of the error.

Operationally, the PES involves the following steps: (a) a sample of geographical areal units is selected from among census EAs by probability sampling, (b) the population in these areas are re-enumerated in the PES exercise, (c) matching of individual records from the PES is done against the census returns, and (d) an estimate is made of the census coverage rate on the basis of the records of matched and unmatched events. Sometimes a field reconciliation is undertaken to determine the correctness of conflicting entries.

In African countries, two varieties of PESs have been experimented with: (a) the traditional PES and (b) the dual record PES 2/.

The traditional PES strives in the re-enumeration exercise to reconstruct the population as of the time of the census and to achieve better coverage than the census operation by using more qualified and trained supervisors and enumerators and paying more attention to other quality control checks (ECA, 1976).

Ghana tried this sort of PES for the evaluation of the 1960 population census. The PES took place two and half months after the census between June and July. A five per cent sample of the 1960 population was selected for the re-interview.

In the manner of the traditional PES particular attention was paid to achieving better coverage than the census. The strategies adopted to achieve this comprised the following: "special measures were taken to obtain a better quality of enumeration than in the main census. The 1,000 interviewers were selected from the best field staff, mostly census supervisors. Seven days intensive residential training was imparted directly by senior officers from the census Head Office" (Ghana, 1964).

Unfortunately, the PES was beset with problems that compromised its main objective - to measure the rates of omission and/or overenumeration. Firstly, there were delays in the implementation of the PES attributable to several factors, chief among which, was insufficient attention devoted to its planning during the main census programming. Also, there was a waning of interest in the operation, especially after the intense preparations for and implementation of the census. The decline of interest in the PES was shared by both the general public and other government agencies whose co-operation by the provision of staff and equipment (especially transport) had contributed to the success of the census operations.

There were also methodological problems in the field. There were differences in the interpretation by interviewers of the definition of "house or compound" in the census and PES. On several occasions, a structure which was listed as one house or compound was divided up by the PES enumerator and considered as two or more separate houses, and vice versa. The differences between this basic enumeration unit in the two operations must have complicated matching.

These problems and others connected with the implementation of the PES resulted in its being unable to effectively be the standard against which the census result was to be appraised. "The coverage evaluation studies ... have shown that the coverage in the main census was better than in the PES supplementary enquiry."

For the Cameroon 1976 population census which took place between 9 to 24 April, a PES on the traditional lines was organised to verify the quality of the enumeration with special reference to underenumeration and overenumeration. The operation took place a month after the census from 10 to 20 June 1976.

The cream of the population census field staff was selected. To maintain some independence between the PES and the census, the field staff was employed in EAs different from those that they worked in during the census. Sample EAs were selected from three strata: the two main cities Yaounde and Douala, the other cities and main urban centres and rural areas. An estimated underenumeration rate of 6.9 per cent was derived from the PES exercise.

The Ivory Coast's attempts at measuring census omission and/or duplication rates were definitely unsuccessful. A PES exercise for the 1975 census took place about a month and a half after the enumeration. Three reasons have been given for the poor result of the operation. Firstly, the survey took place during the rainy season which made working conditions extremely difficult. Secondly, the objectives of the exercise were not clearly stated at the planning stage and were not therefore known at the implementation phase. Thirdly, methodological problems cropped up in the field which could have made attempts at matching well-high impossible. This came about because field officers did not consistently enumerate their assigned EAs and moreover they did not keep the questionnaires in an orderly fashion. As such this exercise could not provide definite answers about the question of census coverage.

The Kenyan evaluation exercise similarly could not provide unambiguous answers about coverage. The problem here was that the PES exercise took place a very longtime after the census. Thus this operation proved unequal to the task of reconstructing the population as at the time of the enumeration despite the procedure of selecting 648 sample EAs in rural areas identical to those in the census and "blowing up" the result for comparison with the census.

Sierra Leone is another country that experienced problems in the implementation of the PES for the 1963 census. The Sierra Leone experience is interesting and worthy of note, because all the preparations and objectives of a traditional PES were faithfully carried out, but because of poor implementation the results were inconclusive about the extent of the coverage rate in the census (Sierra Leone, 1965).

The PES re-interview involved the re-enumeration of 160 sample EAs. The higher level field staff used in the census - the field supervisors were selected to do the PES. To avoid collusion, no field officer was engaged to work in EAs where they had worked during the census.

The re-enumeration exercise initially took place in 150 out of the 160 sample EAs. This aspect of the work presented no major problems with respect to enumeration. But in the remaining 10 EAs, work did not begin until some six months after the census. Moreover the field reconciliation assignment for the 150 EAs took place during the rains, which made work very difficult. The other methodological problem with the PES, despite its special preparations, was that it was prone to omit the same types of persons that the census omitted.

Therefore, the operation was not very conclusive about the estimated underenumeration rate of 3½ per cent derived: "The analysis indicated that the PES results may tend to overstate the undercounting in the census". (Sierra Leone, 1965)

Liberia attempted for her 1974 population census, a different PES from the traditional type (Marks and Rumford, 1978) 3/. The rationale for the use of the PES modelled after the dual record system was based on the following considerations: (a) that the traditional PES despite its use of above average enumerators and supervisors had proved unsatisfactory as a standard against which the census returns are to be evaluated, and (b) that two data collection systems, except patterned on the independence criterion, are prone to underestimate the same sets of events (Marks and Rumford, 1978).

The dual record system estimation method briefly consists of (a) collecting data from a sample of the target population with two independent collection systems (in census evaluation, the census and the PES), (b) matching the reports of the two systems to determine the total number of events recorded in the census (N_1), total number of events from the records of the PES (N_2), and the total number of events recorded in the PES and matched with the census returns (M). From the above the following events can be estimated - estimated number of events recorded in the census but missed by the PES (N_1-M), estimated number of events recorded in the PES but missed in the census (N_2-M). The estimated completeness rate of the census is given by M/N_2.

Specifically the Liberian PES comprised these features, in addition to the following - the use of one-way matching i.e. the matching status of all the records of only one of the systems was determined, and allowing for a brief period between the census and the PES.

To preserve independence, one of the cardinal conditions of the dual record estimation system, the PES sample was selected immediately prior to the national census day. But the sample areas were kept a secret from the field officers until after the census enumeration. The completed enumeration questionnaire forms for each of the sample EAs used in the PES were impounded and were in custody for the whole period, of the enumeration. Moreover, persons selected to do the enumeration were county inspectors and District Supervisors, who although they had participated in the census work and therefore were familiar with its procedure, took no active part in the enumeration.

However, despite the stress on maintaining independence, it was discovered that for at least two out of the thirty-two sample EAs this ideal was compromised. Apart from this, the PES also had its own share of problems. Matching procedures, very central to the method and hence to the result of the evaluation exercise, became problematic. The main reason for this was that the PES questionnaire was so abbreviated that very few times were available to enable unambiguous matching. Arbitrary matching procedures were later adopted as the numbers of unmatched cases were initially very high.

Also, certain mobile and transient population groups, namely, visitors and the floating population (i.e. those with no usual place of residence) that were extremely difficult to enumerate in the census also proved equally difficult to enumerate in the PES.

Accordingly, the Liberian PES modelled after the dual record system, like others in African countries, based on the traditional system, provided inconclusive evidence about the coverage of the 1974 census: "The Liberian system is no panacea. When the final 1974 results become available, all the available methods of demographic analysis will be required to refine and improve the completeness estimates derived from the dual system estimation. Comparison with previous census and survey results will be necessary to fully evaluate the census". (Marks and Rumford, 1978)

DEMOGRAPHIC ANALYSIS

Briefly the demographic analysis approach of the evaluation of the coverage of population censuses involves estimating expected totals of the census by means of demographic techniques. Among the independent data sources used for the evaluation are data from past population censuses, births, deaths and migration data. The expected or "correct" populations derived by this method are compared with census totals in order to provide an estimate of net error.

A major weakness of this method is that the standards set against which the census is to be estimated are in the majority of cases also subject to errors either in the base data or the assumptions used for manipulation (Siegel, 1974). Moreover, a problem concerning the application of the method in African countries is that the independent data sources required for the estimation of the expected population are either incomplete in coverage, e.g. births and deaths statistics from vital registration systems, or not sufficiently accurate themselves, e.g. past population census statistics. It becomes therefore very difficult to distinguish errors that are attributable to the data system that is being evaluated from those of the data source that is used for the evaluation.

Examples of the past uses and review of the problems of the demographic analysis techniques in African countries follow.

In African countries that had had more than one census, a popular method of evaluation involves the use of the average annual growth rate between the censuses. The assumption of this approach is that an annual growth rate of over 3 per cent per annum is hardly the result of the effects of natural increase; in the absence of significant international migration, the likely cause is over-enumeration or under-enumeration in one or the other of the censuses (United Nations, 1955; 9-10). This approach however is only suggestive of the plausible source for the error.

For example, Ramachandran (1980), in evaluating the 1973 census of Libya compared the various rates of growth of the population based on census totals of 1954, 1964 and 1973. But a complicating factor in interpreting the annual growth rates of the recent intervals especially 1964 to 1973 was the extent of international migration which became pronounced after the exploitation of the country's oil resources. The effect of the movement produced erratic growth rates. The growth rate was still erratic, after adjustment for net international migration.

The author considered four options: (a) a fall in fertility rate, (b) an increase in mortality rate, (c) an excess of out-migration over in-migration, and (d) an under-enumeration in 1954 as compared with 1964 and 1973 and/or an under-enumeration in 1973 as compared with 1963.

With no hard evidence to go by, he arrived at the very general and rather ambiguous conclusion that "the only possibility remaining for explaining the anomaly in the growth rate is through enumeration completeness in the various censuses".

The problem of having a reliable standard, in this case, too, previous population census totals against which to estimate the coverage rate of the latest census count is amplified by Nigeria. An attempt to designate the source of error of the obviously very high annual growth rate of 6.3 per cent between 1953 and 1963 proved extremely difficult. The question centred around under-enumeration and/or over-enumeration of the 1953 or 1963 census: "The overall growth rate of nearly 6.3 per cent is obviously too high to be accepted with equanimity. Nevertheless, there are important arguments for resisting the temptation to reject the figures. For example the rates of increase calculated above presume that the 1952-1953 census was itself accurate. There is no reason to believe that this was so, for it was not a complete house-to-house enumeration, as was the 1963 census". (Yesufu, 1968:108)

Ekanem (1972) concurs with the view that the 1953 census total was under-enumerated. He, however, argues that there was also over-enumeration in the 1963 count. The combination of these two factors, he used to explain the high intercensal growth rate: "The reported data revealed implausibly high annual percentage increases ... Only ... possible undercounting at the 1952/53 census, net in-migration and/or possible inflation in the 1963 census could explain such increases". He concludes however that "the one single factor that largely accounted for the observed increases between 1953 and 1963 is possibly inflation in the 1963 census".

In a paper on the evaluation of the 1970 Ghana census, de Graft-Johnson and Ramachandran (1975) examined the various derived annual intercensal growth rates: the total population 2.4 per cent;the Ghanaian population, 3.05 per cent; and 2.75 for the Ghana born population. The annual growth rate of the total population in particular was considered to be on the low side. These various rates of growth, according to the authoris, presented two possibilities on census coverage rates: "that (i) there was an out-migration of a substantial number of aliens during 1960-70, (ii) the Ghanaian population excluded a few persons who should have been included in 1960, and/or included some non Ghanaians in 1970 ..."

Another approach to the evaluation of census coverage, this time with respect to a subset of the population, has been to compare the sub-totals of the population with the relevant group derived from independent data sources, such as school enrolment records, electoral lists and sometimes results of sample surveys. The basic problem here is that there are sometimes of differences between the time reference periods of these data sources and the census, the use of not entirely the same concepts and definitions and accounting for seasonal differences in the population at the two time periods.

In Botswana, for example, for their 1971 population census (Botswana, 1972) a comparison was made between primary and school enrolment statistics from education statistics with the comparable data from the census. The analysis showed that the number of pupils enrolled as shown in the primary school records was higher than the number enumerated in the census, but for secondary school enrolment, the opposite was the case i.e. the number enumerated in the census was higher than those recorded by the education department. But on the whole the rates of under coverage and over coverage were very low (6.7) per cent for the primary school under-enumeration rate and

2.2 per cent over-enumeration rate for the secondary) if account is taken of such factors as differences in concepts and the fact that the census was conducted during the holidays.

In Sudan, Ramachandran (1980) made use of school statistics for the evaluation of the 1973 census relating to the school population. He compared for the census year, the enrolment data for primary pupils with the comparable age group enumerated in the census. In almost all the sub-population groups, the census figures were lower than the figures from the education department, and with the under-enumeration more pronounced for girls compared with boys. The author inferred that because the census was conducted during the vacation, which led to the exclusion of those who had completed primary school at the end of the school year, this led to the under-enumeration.

In Nigeria, unlike Botswana and Sudan, a comparison of the projected census data of one of the regions, the Western, of pre-school children at the time of the introduction of pre-primary education and the actual registered number showed that the difference in the two totals was very large. Eighmy (1968) estimated the relevant age group (2-6) from the 1952/53 census the likely number of the count affected by the introduction of pre-primary education. He came up with a figure of 170,000 as opposed to the actual count of 392,000 in 1953.

A different data set, namely eligible persons from electoral registers and regional survey counts of villages, have been used to compare census coverage of sub-population groups and localities.

Thomas (1979) compared the population count of those aged twenty-one and above from an electoral register with the comparable group enumerated in the 1974 census of Sierra Leone. But electoral registers have, at time, inflated the population of those aged 21 and above for political motives. Accordingly Thomas found out that the electoral list totals when compared with relevant regional census totals had much higher values. He concluded that the electoral roll was the more inaccurate of the two data sources "because of the rather lax procedures used for registering voters in the country (and) ... the gross distortion and considerable inflation of the electoral registers".

In Botswana (1972) population totals of villages surveyed just prior to the census were compared with the figures arrived at the census enumeration. With the exception of one village that was among those included in the Ministry of Agriculture surveys, the rest of the village totals compared very favourably with the census totals.

CONTENT ERROR EVALUATION

The evaluations of content errors of African population census data have overwhelmingly concentrated on age and sex statistics. Given the importance of the age data in the classification of socio-economic statistics and also given the perennial problems of acquiring accurate statistics on this topic in African censuses, this emphasis is not misplaced.

The analyses have mainly comprised of the examination of digit preference and age misreporting. The statistical techniques used include comparison of census data by age with an expected population grouped by age and sex derived by e.g. stable population parameters; assessment of the accuracy of the statistics by means of indices such as Whipple and Myers.

For example, in one of the earliest evaluations of the age-sex data of African countries, Coale and Demeny (1967) made use of stable population models to assess the female age-sex data of a number of African countries (along with those of India, Indonesia and Pakistan). The authors identified the following patterns of age misreporting - a surplus at 5-9: a deficit in the adolescent age intervals (i.e. 10-14 and 15-19) followed by a surplus at 25-34.

Van de Walle (1968), in an extensive study of the age data from African countries from censuses and surveys also used stable population models in addition to other techniques. More importantly, Van de Walle considered in this study the phenomenon of age misreporting in African countries within the socio-economic environment of the data collection process.

After these pioneering studies several others followed as the results of population censuses conducted in Africa in the 1960 and 1970 rounds became available. For example, in the paper "Comparative Analysis of the Accuracy of Census Age distribution for selected African countries" prepared for a seminar of Techniques of Evaluation of Basic Demographic Data in July 1973 (ECA 1975a) evaluations of the age-sex data from a number of African countries were performed. Topics covered included age misreporting and digit preference.

Also, evaluation of the censuses of individual African countries on age and sex data have appeared (see e.g. Ohadike and Tesfaghiorghis (1975 on Zambia), Okoye (1979 on Sierra Leone), de Graft-Johnson and Ramachandran (1975 on Ghana). For example, Ohadike and Tesfaghiorghis, using such techniques as age ratio and sex ratio tests and the United Nations age-sex accuracy index, evaluated the five-year age-sex data of the 1969 census of Zambia. Okoye using the same statistical techniques evaluated the 1974 population census of Sierra Leone.

The above methods of census evaluation could be faulted on two grounds. Firstly, that they are <u>ex post</u> exercises, as such it is difficult from them to ascertain the causes of the errors. Secondly, the evaluations of the age and sex data that use the stable population technique are not able to distinguish deviations from stability that are attributable to misreporting from those due to selective under-enumeration. Moreover, this approach also does not provide insights into the causes of errors (Krotki 1969, Ewbank, 1980).

Studies based on re-interview surveys such as the PES have been the principal sources of our current knowledge about the causes of content error

For example, in Ghana for the 1960 census a special attempt was made to evaluate content errors by comparing information collected in the census with those in the PES (Ghana, 1964: 387-408). The topics of the content evaluation tests were age, birth place, school attendance, type of activity, occupation and employment status. The content evaluation tests were confined to records of 11,852 persons that were matched.

Also in Botswana (1972) a content error evaluation re-interview experiment was undertaken. It consisted of interviews done separately by enumerators and supervisors in 368 households during the 1971 population census. The records on these 368 households, which were made up of 2536 persons reported by the enumerators and 2506 persons reported by the supervisors were matched. The study enabled the evaluation of the data on age, education, occupation, orphanhood (adult mortality) and fertility by the comparison of the two sets of data i.e. those from the enumerators and the supervisors.

For the 1973 population census of the Gambia, Gibril (1974) turned to data from an independent source, the Medical Research Council surveys of villages, to evaluate birth statistics. 4/

These various studies have offered valuable insights into the patterns and some of the causes of content errors. They were however confronted with problems. A prominent one was matching. In African countries with similarity of names and vagueness of addresses, re-interview studies have to contend with matching problems. This problem affected the result of, for example, the Ghanaian experience: "the identity and similarity of names does not ensure the identity of persons. Hence the extreme discrepancies (between the results of the census and the PES) found may be partly a result of wrong matching".

Also the assumption of comparing with the census a better conducted PES thus with better results is not always valid. In Ghana, where special attention was paid to this point, the results were mixed: "although the general assumption that the PES provides a better quality of content ... holds, this assumption cannot be considered definite and universal. In certain respects, the census might provide more accurate data than the PES and in certain other cases, both might be different from the true conditions". These shortcomings render the results of re-interview tests difficult to provide conclusive answers about the causes of errors.

Another method that has been used for the evaluation of censuses, similar to the dual interviews approach is based on the tape recording of the interview process. To estimate content errors, transcripts of the tape recording are compared with the interviewer's recorded entries in the questionnaire books. Response reliability studies that use this method have proved very useful in our understanding of content errors by providing "a clear portrait of the verbal interactions between interviewers and respondents". (Ewbank, 1980:2).

The two main African studies on this type of evaluation of censuses have been by Gibril and Quandt. Gibril (1978) made a study of the 1973 Gambian census, whilst Quandt (1980) based her analysis on the 1971 census of Morocco.

SUMMARY AND CONCLUSIONS

This paper focuses on the problems and practices of content and coverage error evaluation of African Censuses within the period 1960 to 1980.

The uses of the post enumeration survey (PES) in directly evaluating population and housing census results in African countries were reviewed. Two types have been used in African countries - the traditional method, which strives in the re-enumeration exercise to reconstruct the population as of the time of the census and to achieve better coverage than the census operation by using more qualified and trained supervisors and enumerators and paying more attention to other quality control checks. The implementation of this type of PES in African countries, e.g., Ghana (1960 and 1970), Sierra Leone (1963), the Ivory Coast (1975), Cameroon (1976) and Kenya (1979), were not free from problems. The major ones responsible for the PES being unable to provide unambiguous answers relative to the census coverages in these countries were - (a) inadequate preparation, (b) sloppy implementation, (c) vagueness of addresses because of the lack of street names in especially rural areas, and (d) similarity of names.

In Liberia, the only country so far in Africa where the PES modelled after the dual record has been tried, the results were not significantly different from those of the other countries that have used the traditional type, and for similar reasons. Problems such as vagueness of addresses and similarity of names handicapped efforts at matching. Matching was, in any case, a major problem with the Liberia PES because of the very short questionnaire employed. This meant that there were very few items available for comparison to enable unambiguous matching. Also in some sample EAs, the independence condition that is central to this method, was violated.

The experiences of African countries in directly assessing their census enumeration by means of the PES, either the traditional or dual record approach, lead to the following recommendation. For future PESs in African countries to result in unambiguous evaluation of censuses, survey statisticians must institute the following measures - (a) carefully plan the operation, including it as an integral rather than a peripheral element of the census programme, as has been the practice in the past; (b) paying meticulous attention to mapping, especially of the sample EAs for the PES; (c) examine, for example in a pilot survey, the solutions of the problems of similarity of names that have impeded efforts at matching; and (d) instituting at the implementation stage, more strigent quality control checks than in the census.

The paper also examined the demographic analytical technique and methods using non-demographic data as a means of evaluating censuses, with examples drawn from Sudan, Nigeria and Sierra Leone. The review showed that because alternative demographic data such as births, deaths, and past population censuses and migration statistics and the data from administrative sources such as school enrolment figures that were used as models against which the censuses were evaluated were themselves in the majority of cases incomplete and/or not sufficiently accurate themselves, the results of the evaluation exercises did not present clear cut answers.

Relative to the practices and problems of content error evaluation, attention was focussed on the work done on especially age and sex evaluations in the 1960 census of Ghana and the 1971 census of Botswana. Also the experiments of response reliability using tape recording of census interviews (in Gambia by Gibril and Morocco by Quandt) as well as matching of interviews from two sources - a survey and a census result, were discussed. More of such studies should take place in African countries, because of their value in dilineating the causes of census errors, a function the other techniques cannot perform. To get useful results from these sort of exercises, their planning and implementations must be the same as the high standards recommended for the PES.

NOTES

1. This section mainly discusses the post enumeration survey experiences of African countries in the 1970s. For a similar discussion covering the 1960s, see ECA (1975).

2. For a discussion of the differences and similarities of the two type of PESs, though bias in favour of the dual record type, see Marks (1978).

3. One of the authors, Rumford, was the technical adviser of the Liberian census and before that, had conducted a series of demographic surveys in the country.

4. Other studies not based on population censuses have appeared, for example in Nigeria Caldwell and Igun (1971) used a small sample to evaluate age reporting using an event calendar and matching of contemporaries. Also Pison (1978) studied age reporting in Senegal by comparing the ages reported in a survey in 1977 with ages reported in annual surveys in 1962 and 1974. Finally Andoh (1980) used two survey results from Nigeria to do correspondence analysis of a variety of content data evaluation.

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EVALUATION DES ERREURS DE COUVERTURE ET DE CONTENU PRATIQUE ET PROBLEMES RENCONTRES DANS LES RECENSEMENTS AFRICAINS DE 1960 A 1980

R E S U M E

Le présent rapport porte sur la pratique de l'évaluation des erreurs et les problèmes rencontrés dans ce domaine par les pays africains au cours de la période allant de 1960 à 1980.

Les applications de l'enquête post-censitaire (EPC) dans la mesure directe des résultats des recensements de la population et de l'habitation sont examinées. Deux types d'enquêtes de ce genre ont été utilisés dans les pays africains dont la méthode traditionnelle dans laquelle on s'efforce, lors d'un recomptage de reconstituer le chiffre de la population de la date du recensement et de réaliser une couverture plus étendue que dans l'opération de recensement en utilisant des contrôleurs et des enquêteurs plus qualifiés et mieux formés et en ayant davantage recours à d'autres formes de contrôle de qualité. La mise en oeuvre de ce genre d'enquête post censitaire n'a pas été sans poser de problèmes dans des pays africains tels que le Sierra Leone (1963) la Côte d'Ivoire (1975), la République-Unie du Cameroun (1976) et le Kenya (1979). Les principaux problèmes ayant fait que l'EPC n'a pu fournir de réponses univoques concernant la couverture des recensements dans ces pays étaient les suivants :

a) préparation insuffisante;
b) négligence dans les travaux;
c) caractère vague des adresses en raison du fait que les rues n'ont pas de normes notamment dans les zones rurales, et
d) similitude des noms.

Au Libéria seul pays à savoir jusqu'ici en Afrique tente l'EPC modelée sur la double collecte, les résultats n'ont pas été sensiblement différents de ceux des autres pays qui ont utilisé le type traditionnel, pour des raisons analogues. Les problèmes tels que l'imprécision des adresses et la similitude des noms ont gêné le collationnement. Le collationnement posait, en tout état de cause, un grand problème dans l'EPC du Libéria à cause du questionnaire très court employé. Ainsi, il y avait très peu d'éléments se prêtant à une comparaison pour permettre un collationnement sans équivoque. De plus, dans certains districts de dénombrement représentant des échantillons, la condition d'indépendance qui est au coeur de cette méthode a été violée.

Les expériences des pays africains dans la vérification directe de leur dénombrement par l'intermédiaire de l'EPC (soit le type traditionnel, soit la méthode de double collecte) a abouti à la recommandation suivante. Pour que les enquêtes post censitaires futures des pays africains donnent des vérifications catégoriques des données des recensements, les statisticiens d'enquêtes doivent adopter les mesures suivantes :

a) planifier soigneusement l'opération et en faire un élément intégral et non périphérique du programme du recensement, comme c'était le cas dans le passé;

b) veiller de façon méticuleuse à la cartographie, en particulier concernant les districts de dénombrement choisis comme échantillons pour l'EPC,

c) envisager par exemple dans une étude pilote, des solutions au problème de la similitude des noms qui ont gêné le collationnement et;

d) instituer au stade de la mise en oeuvre des contrôles de qualité plus rigoureux que par le passé.

Dans l'étude, on a également examiné la méthode de l'analyse démographique et les méthodes utilisant les données non démographiques comme moyen d'évaluer la qualité des recensements, des exemples étant tirés des cas du Soudan, du Nigéria et de la Sierra Leone. Il y est indiqué que parce que les différentes données démographiques telles que les naissances, les décès et les recensements passés de la population de même que les statistiques des migrations et les données provenant de sources administratives telles que les chiffres des effectifs scolaires à partir les données des recensements ont été vérifiées, étaient elles-mêmes incomplètes et/ou peu exactes dans la plupart des cas, les résultats des évaluations n'ont pas fourni des réponses nettes.

Dans le cadre de la pratique et des problèmes rencontrés dans l'évaluation des erreurs de contenu, on s'est concentré tout particulièrement sur les évaluations des nombres par âge et par sexe dans le recensement de 1960 du Ghana et le recensement de 1971 du Botswana. Par ailleurs, les vérifications de la fiabilité des réponses grâce à des enregistrements sonores des entrevues (en Gambie par Bibril et au Maroc par Quandt) ainsi que le collationnement d'entrevues de deux sources - une enquête et un résultat d'enquête - ont été discutés. Davantage d'études de ce genre devraient être faites dans les pays africains, en raison de leur importance dans la détermination des causes d'erreurs dans les recensements, fonction que les autres techniques ne peuvent accomplir. Pour que de telles entreprises soient couronnées de succès, il faut que leur planification et leur mise en oeuvre se déroulent selon des normes aussi élevées que celles recommandées pour l'EPC.

ANALYTICAL APPROACH TO CENSUS DATA EVALUATION - SOME AFRICAN EXPERIENCES

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INTRODUCTION

Evaluation or appraisal means the measurement of achievement against goals. Evaluative techniques are often necessary to gauge the success or failure of efforts made in regard to massive and multipurpose data collection. A census operation involves data collection by thousands of enumerators from hundreds of thousands of respondents on a variety of topics. The data collected are passed through several stages before being published. A census thus provides an ideal ground for carrying out evaluation studies because at every step and stage in the operation, there is enough scope to introduce errors, biases, deficiencies, etc.

However, the experience is that in considering needs for information, a matter that seldom receives adequate attention is that of accuracy requirements and the recognition of the importance of being able to place confidence in the results. The census is a one time effort which is repeated perhaps once in 5 or 10 years only. In the case of most African countries, other data systems being are not well developed or unreliable. It is therefore imperative that the data collected in censuses is reliable, or at least, one has an idea of the relative accuracy of the data collected and the sources of the errors found.

It is not possible in a massive operation like a census involving the enumeration of the entire population of a country where diverse data are collected from a vast segment of illiterate and non-numerate populations that the data so obtained will be free from errors, biases etc. What one aims at is to minimize these errors and biases. Thus, no one can claim that a census is without its share of problems. A perfect census is impossible. But, we do not require a mathematically precise census. Even when unlimited funds, efforts etc. are expended, one cannot vouchsafe error free censuses. But do we need such precise figures? For many decision making and planning purposes we cannot insist on such perfect data. What we might require is a range of variation (preferably not too wide) in the data being utilized. After all, even with very accurate data, since planning for the future implies some possibilities for variations in either direction, it is permissible to have some small range of variation of the base data, viz. census information. At the same time, one should be aware that wrong data can lead to wrong conclusions and decisions. Not only will the base data errors be carried forward, they may even get compounded and confounded with other errors. Decisions based on wrong data or premises have material, human and other cost implications.

Thus, an evaluation of census results and publication of that evaluation is an essential part of the census. It is not only desirable but is essential and is the sole protection against unjustified attacks on the accuracy of census data and the competence and integrity of its producers. These evaluation studies also will give confidence to the users and will be of great value in future data collection efforts not only in that country but for other countries as well.

OBJECTIVES OF EVALUATION

Evaluation being the measurement of achievement against what was expected, thus has two main objectives (i) measure accuracy, i.e., provide the range of variation of the data for the users in the appropriate analyses and applications of the statistics and (ii) identify the source of errors or biases in order to know which groups or items or methodology produced the errors. This would be useful not only for future data collection efforts but also for proper adjustments for such groups, items etc. Also the spelling out of the various problems in the data collection and the types and varieties of errors and biases encountered might be useful to other countries who might otherwise commit similar mistakes etc.

TYPES AND SOURCES OF ERRORS ETC.

Evaluation studies probe into the quantitative and qualitative aspects of the data. Hence two types of errors that are probed by evaluation studies fall under the broad headings - coverage and content errors. Coverage deals with the completeness and quantitative aspect of the enumeration whereas content pertains to qualitative characteristics being obtained. For example, population size is related to coverage whereas characteristics like age, sex, marital status, etc. pertain to content. There could be overlap of content and coverage as when one wishes to evaluate sub-populations of given age-sex groups where not only size but characteristics play a part.

Coverage may be affected by or affects content. The usual omission of young children from enumeration is a case in point. Conversely, content might affect coverage. For example, if a question on military service is asked or any other question which might have connotation like conscription, taxation, etc., then it can result in omission of the appropriate group. Omission or wrong reporting also might be caused by the questionnaire designs when some detailed questions are only for certain segments of the population. For example, questions on labour force, marital status, fertility, etc. which are for certain segments might induce the enumerators either to omit some of the persons in order to avoid excess work, or shift them to groups which do not require the additional work. Exaggeration, on the other hand, can arise when some benefits are involved as in rationing, old age benefits, voting etc. Enumerators also might inflate group totals, if payments are made according to numbers covered.

A census is intended to be a complete coverage of all persons at a specified time in a delimited territory. One question paramount after the enumeration is - has the census in fact covered all the people in the area? But a modern census does not stop at a head count. It goes beyond an accounting of the number of persons in an area. It collects information on the characteristics of the population. It is very important to have an idea of the accuracy and acceptability of the information collected.

Even though every effort is made to collect as accurate and complete information as is feasible under the existing conditions, the possibilities for errors are many. For example, the count of heads could be defective because of omission or duplication of areas brought in by ambiguities in the mapping or demarcation of boundaries or through physical or other problems. Even when an area is properly identified and

covered, it is possible that owing to one reason or the other, some houses were left out or counted twice. Even when all houses are visited once and only once, some households living within such houses might be omitted. For instance, one of the usual experiences is that one person households are likely to be more omitted than multi-person households. There are cases of persons within households being omitted or duplicated as in many societies where infants and small children are omitted because of fear of the "evil eye", insecurity, misunderstanding of the purpose of the census as being only for grown ups etc. In certain others, young children are reported more than once. This is usually the case in a de jure count among extended family groups. Instances of young male adults being omitted owing to fear that the count may be used for military conscription have been noted especially during colonial times. Omission of young adult males could also be brought in by their mobility and economic activities outside the home. In some societies, young females are not reported for fear of kidnapping and in some others it might be because of social reasons where strangers especially young male (enumerators) are not supplied information about young girls in the household. Inflation of population for political, religious, prestige or other reasons also is not rare. The counting of visitors, transients, nomads, migrant workers and others without a fixed abode has been a problem to all data collection operations and the census is not an exception.

Thus coverage errors could be due to problems in mapping, identification of enumeration areas, field operations (including loss of questionnaires), lack of co-operation from respondents, loss or misplacement of data, processing errors etc.

Even when all the persons in the household, all the households in the housing or dwelling unit, all houses within an area and all areas within a country are fully covered, still the characteristics derived from the respondent could be subjected to varying types of errors and biases. Further errors and biases could be introduced at the subsequent steps in the processing of data.

In societies with a large segment of illiterate and non-numerate populations, it is virtually wishful thinking if one expects to obtain reliable and accurate information on the manifold questions usually asked in a modern census operation. Generally, information is obtained on all household members from either the household head or any knowledgeable adult member/members in the household or even locality. The enumerator does not and cannot see all the reported members in a household either because they are physically absent from the household or are present in the household but cannot be seen because of ill health, social reasons, age (infancy), etc. Thus, the enumerator has no opportunity to assure himself that all persons are reported and that information is not vitiated.

Even when the right information is given, it may be recorded wrongly or not recorded at all. Carelessness is one area of concern in data collection and strict supervisory and other checks are needed to ensure good quality data. Misunderstanding of the purpose of the enumeration, the scope of the census or of questions might lead to biased data. Ignorance, supersition, cultural beliefs, etc. might also affect data quality. There are instances of respondent resistance in supplying information to enumerators especially when the data collection is associated with governmental activity like taxation, conscription etc. Deliberate misreporting is also a feature in certain enumerations.

like taxation, conscription etc. Deliberate misreporting is also a feature in certain enumerations.

There are several instances of deterioration of data quality after they are collected. Losses, misplacements, coding, editing and other data processing stages might vitiate data. Imputations, wrong tabulations, etc. also affect data quality. Great care is needed in order to ensure that errors are not introduced into the data.

METHODS OF DATA EVALUATION

How do we evaluate census data? There are two broad types of techniques of data evaluation - the direct and the indirect techniques. Among the direct methods are the reinterview surveys through post-enumeration checks. Among indirect methods are the internal and external consistency checks and analytical tools for derivation of parameters. The last mentioned method, make use of consistency - convergency criteria (i.e., the derived parameters should be consistent with each other and with the other types of data and information available and they should form a convergent set and not differ too widely among themselves).

Even though it is difficult to utilise indirect methods efficiently to estimate coverage error, there are instances where such coverage errors were detected by these methods.

DIRECT METHOD - REINTERVIEW SURVEYS

A survey conducted shortly after the census field operations are completed is generally referred to as a post-enumeration survey. They are carried out on representative sample areas taking account of the heterogeneity in the data and keeping in view that one should be able to generalise and get information on important special segments of the population. Thus population clusters enumeration area (E.A.) or other geographical units are utilized.

These surveys are carried out for coverage and content error checks and for collecting additional information (in some cases). There are advantages and disadvantages in combining coverage-content error check surveys with one aiming to collect additional information. The advantage lies in obtaining additional information with less cost and time. But, the disadvantage comes through the difficulty in the planning, design and implementation of such combined surveys. There is also the added danger of the increased length of interview resulting perhaps in reduced emphasis and less careful enquiry for some of the topics. Thus the coverage objective could be affected if combined with content error evaluation and both objectives could be affected if additional topics are investigated as part of a post-enumeration survey which aims at both coverage and content error evaluation.

For evaluating content, a sample of households or persons enumerated in the census can be reinterviewed. For evaluating coverage, however, an area sample is required. Two basic reinterview survey designs have been used: (a) one which stresses attaining high accuracy by using better qualified enumerators choosing the most knowledgeable respondents

to provide information, better interview methods, etc. and (b) one which strives for an independent repitition of the census under essentially the same conditions. Matching and reconciliation should be carried out of the census data with the PES. Evaluation of the coverage of a census is thus more difficult with a defacto census and it is more so when there is no reference date.

The timing of a PES should be such as not to be too close to a census or too far from it. For independence of the operations, it is essential that all field data are received back in the office and a period of 2 to 6 months after census field operations, seems to be ideal. This period is sufficient to obliterate some of the memories of information supplied at the census and ensures independence in reporting while at the same time the period is not too long for migration to affect the population seriously.

A few African countries have utilised the PES as an instrument for checking the quality of enumeration in terms of coverage and content. According to ECA (1977) of the English-speaking countries that completed the 1960 and 1970 rounds of censuses in Africa, no ad hoc PES was undertaken in: Botswana (1971), the Gambia (1969), Lesotho (1966), Libyan Arab Jamahiriya (1973), Mauritius (1972), Sierra Leone (1974), Somalia (1975), Sudan (1973), Swaziland (1966), Tanzania (1967 - only a regional study was made), Uganda (1969) and Zambia (1969).

In the 1960 census of Ghana, the coverage and content evaluation survey was c combined with a supplementary enquiry to collect much needed additional information. The experience was that the PES did not serve a very useful purpose as a tool for coverage and content evaluation. According to the census office, "the quest for additional data on the characteristics of the population did complicate the coverage projects and was partly responsible for some of the problems encountered. It might be necessary in future censuses to explore the possibility of separating coverage projects from any additional enquiry that might be decided upon to ensure that the objectives of a coverage check are not compromised by the need to obtain additional data on the characteristics of the population" (Gill and de Graft-Johnson, 1961). Mobility, interviewer attitude to coverage, moving reference date, quality versus quantity, i.e., additio al characteristics versus checking completeness of coverage, and changing definition of house at the two enquiries were the major causes for the failure of the PES.

On the basis of this experience, in the 1970 census of Ghana, the supplementary enquiry after the census stressed more the collection of additional information.

Some of the African countries, however, claim to have succeeded in getting conclusive results from the PES. Liberia (1974) and Cameroon (1976) are important among those who could assess the coverage of population by sex and broad age segments. In the case of Malawi (1965) and Kenya (1969), the PES clearly indicated under-enumeration in the census and these formed the basis for correcting the census totals.

In Libyan Arab Jamahiriya (1973) and Mauritius (1972) there were no PES but data quality and coverage were evaluated by analytical tools. In Sudan (1973), on the other hand, in addition to analytical tools, there were resurveys and check surveys carried out in specific areas and among groups where doubts were raised on enumeration quality. For example, after the census enumeration when preliminary population figures became available, it was noted that the nomadic population was too low as compared with their number recorded in the previous sample census of 1955/56 and also with estimates from various sources. Again, the growth rates of some of the Southern and Western provinces were too low. Also, in the Blue Nile province the enumeration was suspected to be defective. To test these hypotheses and verify enumeration completeness for these segments, the Sudan census authorities carried out a resurvey of nomads and mounted check surveys in Blue Nile, Kordofan and Equatorial provinces.

The resurvey in Nigeria carried out in 1963 after their 1962 census is well known for the controversy it generated. Such resurveys and check surveys might have serious implications. Any vociferous group which is not satisfied with its enumerated population figure might agitate for a recount or check survey and till it is satisfied with the figure, might not accept any figure even though the surveys might have been conducted in the most scientific way. It is essential that no scope is given for any segment or group of population to suspect coverage.

As it is quite feasible that certain difficult areas or segments might be less completely enumerated as compared with the others, a representative sample of areas on a national basis should still be covered to obtain information on ideas about the relative coverage of such segments so that an estimate of the true value can be calculated.

Since it is not always possible to find reliable data from alternative sources, the general recommendation by ECA during the 1970 round of population censuses in African countries was that ad hoc post enumeration surveys should be done for evaluating the census data. Also, it was stressed during the second meeting of the African Census Programme country experts held in Addis Ababa in 1974 that census evaluation should consist of coverage rather than content checking when a PES is undertaken to evaluate the census data. For errors of content, the census data should be evaluated by using methods of demographic analyses.

Even though the experience of African countries in carrying out PES is still inadequate, the common feature of those few PES carried out is that they utilised the available area frames and maps and did not attempt to evaluate the adequacy of the cartographic and other areal preparations of the census. Thus, it seems that what was done was an appraisal of population count within the delimited areas and there was no attempt to check completeness of areal coverage. Some of the major factors contributing to the failure of PES were: (i) population mobility, (ii) unrecognisable boundaries of sample areas, (iii) varying names of persons and many common names, and (iv) general fatigue of enumerators.

INDIRECT METHODS - ANALYTICAL TECHNIQUES

Among the indirect methods we have two broad categories - external and internal consistency checks. In the former, we compare the census result with other external evidence to arrive at the relative acceptability of the census results. In the internal consistency checks, we analyse the data and check whether a broad picture of the reliability of the various information collected emerges. The reliability or otherwise is measured by the criteria of consistency and/or convergency of the parameters and other indices derived from the data such as the age ratio, sex ratio and joint score methods of age sex data evaluation, consideration of growth rates, survival ratios and mean age of population (by sex), mean age of fertility etc. Vital parameters derived from the data by the application of diverse analytical tools especially developed for the analyses and interpretation of defective and incomplete data, are compared for consistency and convergency.

Even though, as indicated earlier, indirect methods are not very powerful in the evaluation of coverage, still under certain conditions these tools could be used with care to arrive at possibilities of errors in coverage.

EXTERNAL CONSISTENCY CHECKS

One of the most important external consistency check is through the use of what is called the 'balancing equation'. Since a population changes by births, deaths and migration, this method utilises any information on these to appraise population figures. For example, if there are two enumerations, one could utilise data from vital statistics and migration figures to obtain a balancing equation:

$$P_1 = P_0 + B - D + I - E \text{ , where}$$

P_1 and P_0 are respectively populations at the second and first enumerations, B, D, I and E are respectively the births, deaths, immigration and emigration figures during the intercensal interval. This equation can be applied for age-sex groups provided such detailed data are available.

As an illustration, let us consider the non-Libyan Arab Jamahiriya population enumerated in the 1954 and 1973 censuses of Libya. There was a growth in the population from 49,000 in 1964 to 210,000 in 1973. During the interval there were 236,700 immigrants and 222,300 emigrants. Unfortunately, statistics of births and deaths are not available for the entire period. For the period 1972-73 we can calculate a natural growth rate based on births and deaths, as 1.4%. Since the age-sex balance was better in the period previous to 1973, it could be that the natural growth rate was much higher. An average growth rate of 1.9% per annum would satisfy the balancing equation in this case. This growth rate is quite feasible for the period and hence it could be assumed that the enumerations are consistent with the other available information (vital and migration statistics).

In countries where census data themselves are suspect, vital and migration statistics are either not available or are grossly deficient. Again, as in the above example cited, the detailed figures might not be available. One modification we

introduced in the balancing equation is the substitution of detailed birth and death figures by the natural growth rate. Thus a modified version of the equation is:

$$P_1 = P_0 + NG \pm MG \text{ , where}$$

NG and MG denote respectively natural and migration growth. Thus instead of the four components, we need only the net effects of natural and migration growth.

In cases where migration is known, as in the example cited, we can proceed as illustrated. But the equation becomes simpler, if migration can be assumed negligible. The equation then will be:

$$P_1 = P_0 + NG$$

Here also the equation can be considered for age sex groups separately, provided such detailed data are available. In most cases, unfortunately such information are not available and one can apply the method only for the total population, perhaps by sex.

Let us illustrate the method by using information from the 1948, 1960 and 1970 censuses of Ghana and the 1954, 1964 and 1973 censuses of Libyan Arab Jamahiriya. Table 1 gives the intercensal growth rates by sex. In the case of Ghana migration figures are not available but in the case of Libya such figures could be obtained (but not by sex) from the 1973 census. Hence for Libya both the adjusted and unadjusted growth rates are provided.

Table 1. Intercensal growth rates (annual geometric) - Ghana and Libyan Arab Jamahiriya (Libyans)

	GHANA		LIBYA		LIBYA (adjusted)	
	1948-60	1960-70	1954-64	1964-73	1954-64	1964-73
Male	.0417	.0225	.0385	.0332	.0365	.0333
Female	.0418	.0263	.0378	.0354		

Obviously, the growth rates in the earlier period are higher than the latter period. This is not plausible, unless either fertility fell or mortality increased. In the case of Ghana it could also be due to migration. But, actually from every evidence, it is known that migration was heavier between 1948-60 than before and there was an exodus after 1969. In Libya, on the other hand, there was a slight over reporting in 1964 due to an impending election. Thus a large under-enumeration in the earliest census seems to emerge. Also, it looks that the latest census might have enumerated most of the population.

A related method based on calculation of survival ratios of groups is yet another tool, even though this is strictly an internal consistency technique and will thus be considered in the next section.

Other types of external consistency checks are those based on comparisons of specific age-sex groups in the census with data from other sources. For example, children of school age, school going children, persons of voting age, working age, etc. could be compared with data from school statistics, labour bureaux, electoral rolls, rationing authorities etc. However, one has to be cautious in interpreting the findings, as sometimes, it is known that the independent external sources used for comparison might be subjected to similar types of errors as those in censuses or may have different types and magnitudes of biases and errors and hence may not be strictly comparable.

As an illustration of the application of the method, let us consider the non-Libyan workers from the 1973 census and the independent data from the manpower statistics. The census showed 117,524 persons of non-Libyan origin reported as workers in the country as of 1 August 1973. The registered numbers were 117,344 as on 20 June 1973 and 128,000 on 20 September 1973. Since it is known that during the census time a few expatriate teachers were not included in the count, the two systems seem to be consistent within reasonable limits.

Another data compared is of children in primary schools. The Ministry of Education compiles statistics on number of children in schools and in 1973 there were 259,729 males and 196,131 female children in schools as against the census figures of 250,556 males and 184,329 females. The timing of the two systems might have brought in some of the differences. Otherwise there is good agreement.

It is important to point out that all the above methods are not conclusive and even if perfect agreement is shown between the two sets of data, one cannot conclude that they are acceptable. This is because compensatory errors could vitiate conclusions, or that both systems may be riddled with same or similar types of errors or biases. These are necessary conditions for acceptability of data but are not sufficient. One has to carry out other exhaustive tests before final conclusions can be drawn. Some of these will be described below, but they also are not entirely free from the defects mentioned earlier.

INTERNAL CONSISTENCY CHECKS

Among the internal consistency checks are those based on patterns in age, sex and other data, reasonableness or acceptability of some of the observations and derived parameters over time and space etc.

AGE

One of the most important items collected in all censuses is that on age. Not only are demographic phenomenon like fertility, mortality and migration closely related to age, but so also are socio-economic and other characteristics. Also, age can be used as a tool for estimating some of the demographic parameters and in developing societies without direct data on vital parameters, it is data on age which are generally utilised to arrive at such parameters.

Thus, not only is it true that age is one of the few information collected in all censuses, it is also one of the more thoroughly examined, analysed and adjusted characteristics. This perhaps is due to the practical needs and uses of age data.

Though age is an easy concept to understand, when it comes to measurement, there are several problems. First of all, age could be in completed years, age nearest or next birth day etc. What is a year? To a Western man or to one who is familiar with that system it connotes a solar year. But to a Muslim it means a lunar year. To yet others, it may be quite a different thing. Again, what is a birth day? Very few people in developing societies celebrate birthdays and no importance whatever is put for the event. Age reckoning, if it exists, is based on other criteria like seniority, number of harvests since birth, seasons, floods of rivers, positions of planets and so on.

Even though there are tremendous variations in the reckoning of age among societies, it is possible to convert age in one system approximately to that in another. Thus the real problem in age estimation is not the different systems adopted, it is ignorance of when a person was born. Deliberate misstatements of age due to one reason or the other could create problems.

When ages are not known to the respondents, they are estimated either by them or by others (including the enumerator). The first approximation in the estimation process of age is to put a person into one of the appropriate decennial groups. Thus a large number of persons are reported as aged 10, 20, 30, ... When efforts are made to estimate age more accurately within decennial groups, the tendency is to allocate persons to mid points in the ranges. Thus digit 5 comes out as a second preferred digit. Still further approximation within the five year groups coupled with preference for even over odd digits in many societies bring in the phenomenon of large percentage of population being reported with end digits 2, 4, 6 and 8 and very few being reported with end digits 1, 3, 7 and 9. This kind of digit preference or age heaping has been noted in a large number of developing countries. However, the tempo of preference or avoidance of specific digits varies over the age range. For example, by age 50 and over, the percentage of those with end digits 0 and 5 is much larger than those in the younger ages. By age 70, most of the people are reported in ages ending in 0 and a few in 5. Rarely do we find any one reported with end digits other than 0 and 5 at the old ages. For example, the blended percentages at various digits reported at the 1973 census of Sudan given below clearly shows the overwhelming attraction for digits 0 and 5 and repulsion of odd digits like 1, 3, 7 and 9.

Table 2. Myer's blended percentages by sex - Sudan 1973

Digit		0	1	2	3	4	5	6	7	8	9
Percentage	M	22.7	5.2	8.5	6.3	5.3	21.4	6.4	8.2	9.8	6.3
	F	25.4	4.5	7.8	5.4	5.0	22.6	5.8	7.4	9.8	6.3

Again, for the same data, whereas around 50 per cent were reported with end digits 0 and 5 among those aged 50-59, the corresponding percentage among those aged 20-29 was only 31 and those aged 60-69 was near 60. A systematic increase in the preference for digits 0 and 5 are seen in such reportings.

Many methods have been tried to arrive at better quality of age data. One method is to ask for age next birthday or age nearest birthday. But the experience has been that this just shifts the preference to other digits. Another approach is to ask the year of birth instead of age as in the 1969 census of Zambia. This also did not help as the preference shifted to year of birth resulting in preference for digits 9 and 4 because the census was in a year ending in digit 9. On the other hand, the question on year of birth might result in larger proportions of age not stated, as noted in the 1974 sample census of Zambia where about a fifth of the population were returned as 'age not stated category'.

If enumerators are cautioned about the occurrence of digit preference, then it may result in other types of preferences as happened in the case of the national demographic survey of Guinea carried out in 1962 when the preferred digits became 1, 4, 9 and 6 and overwhelmingly 0 and 5 were avoided.

One method recommended in cases where possible, is the use of historical calendars or documentary evidence. For instance, the 1973 census of Libyan Arab Jamahariya utilised the identity cards issued to the citizens for the estimation of age. But it was noticed that age had been estimated at the time of issue of these documents and the reference date used seems to be 1964 (the previous census). Since digits 0 and 5 were preponderately returned at the time of issue of these cards, the effect was that in 1973 a large proportion of the population were returned with ages ending in digits 9 and 4. Those whose ages were estimated without reference to these cards, however, had the usual preference for digits 0 and 5, as shown in table 3.

Table 3. Myer's blended percentages by sex - Documented and estimated ages, Libyan Arab Jamahiriya, 1973

		DIGIT									
		0	1	2	3	4	5	6	7	8	9
Document	M	7.9	9.9	8.4	9.8	14.0	9.2	8.5	10.4	7.6	14.4
	F	8.7	9.1	8.0	10.3	13.7	10.8	7.9	9.7	7.6	14.3
Estimate	M	14.2	8.1	10.0	9.3	9.1	14.2	8.4	9.4	9.6	7.3
	F	23.0	5.3	8.1	6.3	6.5	20.9	6.7	7.7	9.3	6.0

Even though another type of error appeared in the age data, one important finding was that for small children this method might not be in too much error and hence in the future this method might improve data quality on age. Also there will be more consistency on age data over time even for the others whose ages in the document might be in error.

The use of historical calanders might bring in preferences for certain ages because of the reporting of a large number of events around important dates as happened in the Sudan 1973 census when dates of births were mostly clustered around significant historical events like the May 1969 revolution, the independence of the country etc.

In addition to preferences and avoidances of certain digits, there are preferences or avoidances of certain ages. Age 13 is usually avoided, except in the 1970 census of Ghana. Preference for age 30 as noted in the Liberian census of 1974 might be du to the conception of older and younger persons. A person aged 31 or over is considered as old whereas those less than 30 are young. Thus 30 becomes the dividing line between the two groups and the fact that 0 is a preferred digit adds to the attraction and thus age 30 comes out to be the modal age. Because of certain legal requirements or benefits sometimes ages 18 or 21 are preferred. Another phenomenon observed is a shift of small children to ages 6 or 7 owing to minimum age at entry into schools.

Certain ages could be overwhelmingly reported if they become cut off points for some characteristics. For example, if age 12 is considered as the minimum age at entry into labour force, this can either push persons up or down that age. Such errors also could arise when certain detailed information are required only for persons above a stipulated age. For instance, if fertility data are only for those aged 15 and above, then there would be a tendency to push persons to younger ages. Similarly for manpower and labour force data. However, if there is a payment for this kind of added work, it could result in an opposite pattern.

Thus single year of age data are affected by several types of errors and biases, but all the same it is highly recommended that every effort be made to collect such information.

Even when data are presented in five year or other age groupings, certain undulations are noticed for several reasons. Sometimes there are omissions of persons of certain age groups and other times this may be due to pushing persons across critical age boundaries.

One of the commonest observations in developing countries is the relative shortage of infants and children in enumeration. This could be due to deliberate omission, misunderstanding of the scope of census or age estimation error. In societies where infant and early childhood mortality is high, the fear of the evil eye is an important factor affecting coverage of this age segment. The coverage could be more for one sex than for the other. It could also be that deliberately the sex is misreported. For example, in some societies the female child is not considered as important as a male child and in such cases the reporting of female children, female births etc. could be less than expected. On the other hand, in some others, because of the fear of the evil eye, not only is a male child hidden from strangers but there are instances as in Kenya and other Eastern, Central and Southern African countries of male children being reported as female to confuse the evil spirits (ECA, 1979). In many societies, a small child is not considered as a personality and hence is not included in counting and in some others it might be due to the high mortality which takes away a large proportion of the children and makes the parents think that the children may not survive for long and hence there is no point in including them in the household. Of course in many communities, counting per se is taboo and wrong figures are deliberately supplied to avoid retribution from God.

In some cases children aged 3 or 4 are reported as 5, 6 or 7 to enable them to be enrolled in schools. One reason attributed for the bloating of the 5-9 age group in census enumerations is this kind of shifting. Some older children also might be reported as younger for similar reasons. The 1973 census of Libyan Arab Jamahiriya indicated that such bloating of the age group 5-9 years might have happened owing to the provision of educational facilities in recent years. In a neighbouring country - Sudan - such a phenomenon has been observed. Here, when a child is admitted to a school, the authorities estimate the year of birth such that it coincides with the minimum age at entry into school. After estimating the year of birth, the date and month of birth are given as 1 January. Thus we see among educated Sudanese a large proportion with birth date falling on 1 January. In societies where education is free, compulsory or has immediate monetary or other benefits for the parents or children and where the parents are becoming aware of the need for and importance of education in modern living, there will be a large increase in the entry into the education system from younger and older children and the reported age might be affected.

In societies where children are liked and the extended family system exists, a dejure count might result in some duplication of very young children as they may be reported by more than one household where they spend their time. Such duplication is suspected in the 1955/56 sample census of Sudan, especially in rural parts.

The reporting of age of males and females differs at puberty and post-puberty ages. Young unmarried girls usually are reported as younger than their true age. However, if they are married and have children, they are reported as older but within the reproductive age group. One can notice a deficit of males in the reproductive ages and an excess of females. Part of the male deficit in the young adult ages might be due to their mobility. Deficits of males aged 15-29 have been noted, for example, in the 1967 census of Tanzania.

In a society where knowledge of age or date of birth is not of any importance and even when it has advantage but people are illiterate, ignorant or apathetic, then one finds that the enumerator faces the problem of a large segment of the population who are unable to report their date of birth or approximate age. Usually, the enumerator has to estimate the age of every person in the household - those whom he sees and many whom he does not see. He utilises a calendar of historical events, age-grade cohorts, phsiological changes, documentary or other evidence, physical appearance, marital and fertility status, seniority among members in household, relationship of members etc. In the 1962 census of Liberia, for instance, it is reported that more than 90 per cent of people had their ages estimated.

In spite of all these, it is quite possible that some persons might still be reported as 'age not stated'. In most countries where people have not reported their ages, imputation is done at the office based on other characteristics. Serious reservations have been raised about imputations etc. and every effort must be made to collect all information in the field itself (Banister, 1980). It is much easier and safer to estimate ages of persons while still in the field.

When age data show undulations, they could be genuine reflections of past behaviour of fertility, mortality and migration. In most cases, if these factors could be assumed not to have much effect on specific age groups, then the progression of population from one age group to the next should be more or less smooth. An age pyramid distinguishing males and females would be a good graphical representation and would compare not only age progression but also sexwise differentials.

For quantification, the calculation of age ratios would be useful. The UN definition of an age ratio as hundred times the ratio of population in an age group to the average in adjacent groups has been modified by Zelnik (Shryock and Siegel, 1973) who defined it as hundred times the ratio of population in an age group to the average of itself with the two adjacent groups and by Ramachandran (1980) who modified it by considering in the denominator a weighted average of the three groups as taken by Zelnik but gave double weight for the mid group. The modifications were instituted to remove some of the biases in the age ratio as defined by the United Nations. The third method not only removes some of the biases, it also accounts for digit preference errors, which are usually preponderant in data.

These ratios are calculated separately by sex and of necessity the groups should all have the same number of individual ages in them. The age ratios generally should not fluctuate too far from 100. Thus, an index of vertical consistency can be taken as an average of the sum of absolute deviations of age ratios from 100. This is called the age ratio score.

One method of reducing undulations in the data is by grouping the population into appropriate or broad groups. For example, one of the usual types of fluctuations is that brought by the excessive digit preference. By grouping the data in such a way as to put the preferred digits in the middle of the group a reduction of some of the fluctuations may be effected. Sometimes, unequal age groups might have to be formed when one digit exerts tremendous attraction of neighbouring digits, as usually happens with digit 0. In such a case the group might include digits 7, 8, 9, 0, 1, 2 and 3 with the next group having digits 4, 5 and 6 only. The choice of grouping could be determined either by basing on blended percentages (Myer's, Carrier's or Ramachandran's (Carrier, 1959; Myers, 1946 and Ramanchandran, 1965) or using the criteria of minimum joint score. Table 4 presents the Myer's blended sums and UN scores for various age groupings based on the 1973 census data from the Northern region of Sudan. It is obvious that whereas the blended sums are lowest for group 3-7 for males, it is 4-8 for females. Overall the 4-8 grouping shows the least sum. But the picture depicted by the score method is opposite, i.e., the score is largest for 4-8 grouping. It looks the best grouping would be 2-6 or 3-7.

Table 4. Sum of blended percentages and age ratio, sex ratio and joint scores Under various quinary age groupings, North Region Sudan, 1973

Grouping	Blended sum		Age ratio score		Sex ratio score	Joint score
	Male	Female	Male	Female		
0 - 4	48.67	48.68	16.66	19.63	9.69	65.36
1 - 5	47.85	46.49	15.95	19.70	10.03	65.74
2 - 6	48.91	47.67	12.32	16.86	11.01	62.21
3 - 7	48.92	47.59	12.13	18.51	11.11	63.97
4 - 8	51.21	50.81	16.00	21.38	11.68	72.42

If unconventional age groups are necessitated by the quality of the data, then the usual age grouping could be derived by appropriate interpolation formulae.

One of the important problems is that even though it may be indicated that an unconventional age grouping is more suited to the data in a country, tabulation of characteristics like fertility, mortality, economic activity etc. are made for the conventional and quinary age groups. It has been noted, for example, in the 1960 census of Ghana, because of digit preference, economic activity rates for females showed a zig zag pattern. It would have been better if the tabulations were prepared for the most suited age groupings and then interpolated to arrive at conventional age groupings for national and international comparability.

The fluctuations in the age ratios can be seen from the following table (table 5) based on age reportings from some African countries from their latest available census. The higher fluctuation among the data for females is clear as also the effect of digit preference on the ratios.

Table 5. Age ratios for some African countries around 1970

Country	Ghana (1970)	Kenya (1969)	Libya (1973)	Uganda (1969)	Zambia (1969)
Age					
			Male		
5- 9	113	103	105	99	104
10-14	91	97	100	100	96
15-19	97	98	65	91	94
20-24	89	94	95	88	89
25-29	102	99	100	109	101
30-34	103	93	91	100	96
35-39	101	106	107	103	115
40-44	90	91	99	93	86
45-49	98	106	108	98	116
50-54	109	92	94	111	80
55-59	78	98	90	79	142
60-64	121	108	10[illegible]	124	64
			Female		
5- 9	114	104	108	101	106
10-14	89	92	96	91	88
15-19	88	98	84	92	90
20-24	104	94	93	96	110
25-29	102	110	108	112	97
30-34	106	89	84	97	102
35-39	92	106	118	97	104
40-44	102	94	91	99	88
45-49	89	96	108	89	109
50-54	115	105	96	125	92
55-59	72	88	82	69	103
60-64	126	114	116	139	83

SEX

Sex is another most important characteristics in demographic enquiries. Many demographic, socio-economic characteristics are sex specific. Data classified by sex not only have analytical importance, but often they can be used as tools of evaluation.

Even though the definition and classification of sex are easy and sex is generally easily ascertainable, still census data have their due share of problems arising from classification of data by sex. As mentioned earlier, there are several reasons why one sex or the other is either misreported, wrongly reported or not fully reported. Reporting of male children as female, wrong reporting of age for specific sex groups and omission or duplication of one sex group or the other have been noted in censuses. There are some African societies where the male and female names are sometimes similar or even the same. In some others the female name could be different from the male only for the last consonant (for example some Arabic names). Great care should be taken to instruct the enumerators to fill up the sex and relationship columns, even if they look obvious and redundant to them. Otherwise, what happened in the 1970 census of the Philippines where because in some schedules the sex and relationship columns were not filled up in the field but had to be imputed in the office (Manila), many males were wrongly edited as female because the ending of many male names are 'o' and female names 'a' and an 'o' could be written similar to an 'a' but not vice versa.

It has been noted that coding male and female as '1' and '2' respectively might lead to errors, if care is not taken to write these numbers very legibly. It seems better to code them as 'M' and 'F' or '1' and '3', as done by the ECA in their recent Zambian survey data (ECA, 1981).

One common feature of African age data is that females report themselves to be in the reproductive ages even when they are younger or older. For men, the usual pattern is for them to exaggerate their ages so that the proportion of old males is not in tune with the mortality pattern and level. Thus the sex ratio at the reproductive ages will be low and it will be high at older ages. Also the sex ratio at the very young ages are usually very low, perhaps due to omission of male babies or wrong reporting of sex or shifting (see table 6).

Table 6. Sex ratios by age for some African countries around 1970

Country	Ghana (1970)	Kenya (1969)	Uganda (1969)	Zambia (1969)
Age				
0- 4	99	101	98	97
5- 9	101	103	100	99
10-14	105	108	110	107
15-19	105	103	100	94
20-24	81	95	89	70
25-29	85	85	93	78
30-34	89	94	102	81
35-39	102	95	109	99
40-44	99	96	104	102
45-49	113	105	113	112

One method of detecting age shifting is by the calculation of mean age of the population. There should not be much of a sex differential. As an illustration, for the Sudan, the 1973 census data produced mean ages of males and females as 22.3 and 22.0. Not only are they high, the male value should have been lower than the female. This exaggeration of age is clearly reflected in the mean age of the fertility schedule in Sudan of 28.5 which is too high for an early, universal marriage society.

Another evidence for sex reporting errors is by the use of the reverse survival ratio method. The male and female birth rates should not vary much. The application of the reverse projection method would bring forward the age shifting errors by showing that whereas in the case of the male, the reversed population at old ages would be very large; in the case of the female, the opposite would occur. Incidentally, the application of the forward projection method would indicate an opposite trend - the male survivors at older ages would be very few and those among females quite large.

Thus, in addition to differential age shifting for the two sexes, there could also be differences in coverage. A principal tool to detect such errors and biases is through calculation of sex ratios by age (sex ratio defined as males per 100 females). The sex ratio at birth is usually above 100 and does not show much variation over time. In African societies not subject to considerable out-migration it is usually observed to lie between 102-104. The effect of mortality is generally to reduce the sex ratio by age with certain specific causes like maternal mortality dampening or slightly reversing the pattern. Sex ratios are usually calculated for comparable age groups only of the two sexes.

Since sex ratios generally decline from one age group to the other, an index of horizontal consistency can be defined as the average of the sum of absolute deviations of consecutive sex ratios. But, if one wishes to account for the curvilinearity of sex ratios by age, it looks as if a better index would be an average of the sum of absolute second differences. It is advisable to restrict the calculation of the ratios to age groups with the same number of individual ages in them and exclude the extreme ages (old ages-due to small numbers involved). This gives the sex ratio score.

VERTICAL AND HORIZONTAL CONSISTENCY CHECKS

Based on the age ratio by sex and sex ratio scores, the United Nations has derived an index of accuracy of age-sex data by taking the sum of the male and female age ratio scores and three times the sex ratio score. This is known as the Joint Score. The larger weight of three given to sex ratio score is due to its lesser variability as compared with age ratio scores. It is not clear why the weight should be 3. One method of determining the weights seems to be to base it on discriminatory or classificatory analysis with the constraint that the male and female age ratio scores should have equal weights.

Experience indicates that if the joint score is less than 20, then the data could be considered reliable. Between 20 and 40 the data may be considered usable but might need adjustment and one has to be cautious in the interpretation of results based on such data. When it is between 40 and 60, it is considered deficient and care should be exercised in the use and interpretation of the data and massive adjustments might be called for. Beyond 60, the data is considered grossly deficient and it is risky to utilise such data for any inference.

For example, the age ratio, sex ratio and joint scores for Libya from the 1954, 1964 and 1973 censuses given in table 7 clearly indicate that whereas the recent data might be considered usable, the 1954 data seems grossly deficient and the 1964 data is intermediate. Since the sex ratio score contributes largely to the joint score, any error in sex distribution is reflected. In Libya, the high sex ratio of the population might be partly due to omission of females and partly a reflection of the actual situation which shows mortality. Thus part of the increase in the joint score could be through genuine reasons and the score exaggerates somewhat the poor quality of data.

Table 7. Age ratios, sex ratio and joint scores - 1954, 1964 and 1976 (Libyan)

Year	age ratio score		sex ratio score	Joint score
	Male	Female		
1954	16.0	31.5	19.4	105.7
1964	13.4	21.1	14.4	77.7
1973	5.6	10.9	6.1	34.8

In the case of Sudan, the 1973 data gave a male age ratio score of 17.7, a female age ratio score of 20.7 and a sex ratio score of 9.6 resulting in a joint score of 67.2 which clearly indicates the poor quality of the data. Detailed analyses showed not only age-sex reporting errors, there was also suspected to be massive omission of parts of the population in some parts of the country.

DIAGONAL CONSISTENCY CHECKS

The age and sex ratios give the two dimensions - vertical and horizontal - in the evaluation of the consistency of data. There is yet a third dimension, i.e., diagonal consistency - based on survival ratios of cohorts. These ratios could be for specific age groups or for open ended ages. The latter type of ratios are not much affected by age reporting, but this becomes their weakness as a tool for evaluation.

Table 8 and 9 present respectively the intercensal quinary and open ended (overall) survival ratios for the Libyan population from the 1954, 1964 and 1973 censuses. Whereas many survival ratios in table 8 are larger than unity and others are near unity for the period 1954-64, for 1964-73 only one or two are above unity and others are not unduly large. The oeverall ratios are all below unity, but the ratios for the earlier period are abnormally large and larger than for the later period.

Table 8. Intercensal survival ratios by age and sex 1954/64 and 1964/73 (Libyan)

	1954/64		1964/73	
Age	Male	Female	Male	Female
0- 4	1.1104	.9452	1.0346	.9914
5- 9	.8739	.8570	.8240	.7837
10-14	1.0410	1.1436	.8506	.9173
15-19	1.3101	1.4523	1.0279	1.0747
20-24	1.0646	1.1482	.8494	.8543
25-29	.9852	.9134	.7931	.7685
30-34	.9881	.9636	.6870	.8533
35-39	.9534	.8495	.8793	.9010
40-44	1.0471	.8922	.9123	.8681
45-49	.8588	.7074	.8387	.8321

Table 9. Overall survival ratios by age and sex - 1954/64 and 1964/73 (Libyan)

	1954/64		1964/73	
Age	Male	Female	Male	Female
0 + 4	.9797	.9509	.8722	.8726
5 +	.9581	.9517	.8368	.8450
10 +	.9741	.9697	.8397	.8596
15 +	.9621	.9415	.8376	.8491
20 +	.9043	.8596	.8077	.8112
25 +	.8735	.8077	.7996	.8026
30 +	.8474	.7831	.8011	.8064
35 +	.8172	.7425	.7810	.7944

The under-enumeration in 1954, the slight over-enumeration in 1964 and the age shifting all seem to have brought forward the undulations in the ratios. Some sex selectiveness in enumeration and coverage also is shown up by the ratios.

In addition to the index suggested earlier, one could use the Brass logit or other methods to those survival ratios and calculate life tables and other mortality estimates. It would immediately become obvious that the life table based on the 1954/64 ratios would be unrealistic. Yet another approach is the one suggested by UN where the survival ratios are converted to mortality levels either using model life tables or other analogies. The fluctuations and the unrealistically huge levels would indicate the errors and biases in the data.

OTHER INTERNAL CONSISTENCY CHECKS BASED ON STRUCTURE OF POPULATION, COMPARISON WITH MODELS, CALCULATION OF RATIOS etc.

One attempt worth trying is to match the observed age-sex data with models or analogies. Either the ratios of percentages at various ages or differences of cumulated percentages could be considered. In the first case the sum of absolute deviations from unity could be the criterion, whereas for the latter it could be the sum of absolute differences themselves. If some vital parameters are known, the the matching is easy. If not, trial and error might indicate which set would produce the least deviations and the parameters shown by the set with least deviation could be compared with those from other sources. A similar procedure has been suggested in UN Manual IV (UN, 1967) for studying patterns of errors in age-sex data.

Yet another fruitful method is based on several types of ratios obtained from the reported data. For example, child woman ratio, child adult ratio, dependency ratio etc. could be computed and compared with model values. Table 10 presents some results from the application of the method to the 1973 Sudanese data. A trial and error method may have to be applied before conclusions can be drawn.

Table 10. Special ratios based on 1973 age sex data and on models

Ratio	Sex	Sudan	Model*	Ratio	Sex	Sudan	Model*
P_{5-14} / P_{5+}	M	.358	.320	P_{0-4} / P_{15-44}	M	.441	.419
	F	.333	.313		F	.389	.412
P_{5-9} / P_{20-49}	M	.512	.397	P_{0-9} / P_{15-49}	M	.815	.694
	F	.444	.389		F	.724	.681
P_{0-14} / P_{15+}	M	.888	.792	Dependency Ratio	M	1.079	.944
	F	.809	.763		F	.955	.936

*The model was selected after several trial and error approaches and is the Coale-Demeny North model stable population with level 11 and growth rate 2.5%

Even though these methods are laborious, it looks that the computer can be used for carrying out the matching process, once the inputs are fed into the computer. Another similar procedure worth trying is that suggested by Brass (Brass and others, 1966). In this method the age equivalents of the deviations of the cumulated percentages at ages upto 5, 10 ... are plotted and the highest and lowest deviations are utilised to select an upper and lower stable population. It looks that an average of the upper and lower might fit the data on hand.

METHODS BASED ON ANALYTICAL MANIPULATION OF AGE SEX DATA

We have already referred to the application of projection (reverse and forward) for the evaluation of data and for derivation of vital parameters. In the calculation of birth rates based on reverse projection of population at your ages, whereas the reversal of the entire population is recommended in most cases, in cases where migration is substantial, it looks better to apply a restricted reverse projection of the young ages only.

One important application of forward projection is that suggested by Coale-Demeny (UN, 1967). In this method, the enumerated population is projected by using various survival ratios and the survived populations are compared with a later enumerated population. Since reporting errors could vitiate the results, the method suggests using 7 or 9 values of the survived populations and the median value of level of mortality is recommended as depicting the mortality condition of the period. The method obviously needs data from two enumerations but these need not be 5 or 10 years apart. However, since survival ratios from models are generally available in quinary ages and age data also may be in quinary ages, it is advantageous if the intercensal interval is a multiple of 5 or the period could be made a multiple of 5.

Table 11 produces the results of the application of the method to the 1973 Libyan data. The median levels come to 12.5 for males and 10.5 for females - with average 11.5 Even though the average looks reasonable, the wide difference between the sexes is indicative of errors in the data. There was in fact a substantial pushing down of persons from age 10 and above to ages 5-9. This was more so for females. The reason seems to be (i) the instruction to enumerators to fill up economic activity and marital status and fertility questions for those aged 10 and above (ii) some shifting of children aged 10-14 to ages 5-9 owing to schooling.

Table 11. Overall survivors of 1964 Libyan population by sex under various mortality levels (South model) compared with estimated 1974 population based on 1973 census*

Age	Male			Female		
	Population in 1974	Projected population	Mortality level	Population in 1974	Projected population	Mortality level
10+	680784	687313	10.5	625824	627887	9.5
15+	538065	539316	7.5	495558	499321	7.5
20+	4460o6	445213	11.5	412055	410787	11.5
25+	372931	374476	14.5	344229	344538	12.5
30+	309861	310418	12.5	281302	279728	9.5
35+	256748	257149	14.5	232532	232945	10.5
40+	203646	202588	16.5	180051	179794	13.5

*Since the intercensal interval was 9 years, the 1973 population was carried forward for one year by a growth rate of 3.7%.

A similar procedure proposed by Ramachandran and Nair (1970) is based on tables of survival ratios which could be compared with observed ratios. The additional information needed is the intercensal growth rate. In addition to such tables based on the Coale-Demeny four families, Carrier and Hobcraft (1971) have given some tables for growth rates of 1, 2 and 3 per cent based on Brass logit models. If the intercensal growth rates are known, then this method seems easier but the differing growth rates of age segments because of drastic fall in mortality might vitiate results.

An allied method which can be used to evaluate data and derive estimates is due to Hardy (de Graft-Johnson and Ramachandran, 1975). In this method, the difference between two age distributions given at two points of time is converted into a death rate by estimating the relation between deaths of persons alive at a first census and those among the births of the intercensal interval. Either vital statistics or models or analogies are used.

An important method for checking consistency of age sex data is that based on cumulated age distribution. If approximate stability can be assumed, then using available stable models, we can derive vital parameters when some ideas are available about growth rate, gross reproduction rate or mortality level. Table 12 illustrates the use of this method. It is clear that for an assumed level of 13 from Coale-Demeny North model, the observed age distribution indicates a growth rate of about 2.1 and GRR of slightly more than 2.5. The fluctuation from age to age is not significant, indicating acceptable quality of data. The UN joint score of 33.8 confirms this.

Table 12. Estimation of GRR and growth rate from cumulated age data (using North Model level 13) - Lesotho 1976

Upto age	Cumulated %		GRR		Growth rate	
	M	F	M	F	M	F
10	27.99	26.05	2.44	2.30	1.97	1.75
15	41.21	38.59	2.65	2.47	2.26	2.01
20	51.39	49.28	2.66	2.56	2.26	2.13
25	59.81	58.14	2.62	2.58	2.22	2.16
30	66.86	64.97	2.57	2.50	2.15	2.07
35	72.49	70.50	2.47	2.42	2.01	1.93
40	77.74	75.26	2.42	2.32	1.94	1.78
	Average (median)		2.57	2.47	2.15	2.01

The complementary problem of estimating mortality level from age distribution under assumed growth rate or GRR would also give indication of data quality and level of mortality. We can derive crude birth and death rates and compare with known or estimated values. Table 13 presents the analysis of data from Lesotho, 1976.

Table 13. Level of mortality and birth and death rates based on observed age data and estimated growth rate and GRR (North model stable)

Age	Cumulated pop. %		Level of mortality r=2.1		GRR=2.5	
	M	F	M	F	M	F
5	14.63	13.69	16.4	18.6	7.5	5.8
10	27.99	26.05	14.7	17.6	11.5	8.3
15	41.21	38.59	11.7	14.2	16.8	12.4
20	51.39	49.29	11.4	12.8	16.9	14.2
25	59.81	58.15	12.0	12.4	15.9	14.3
30	66.86	64.98	12.7	13.5	14.5	13.2
35	72.49	70.51	14.1	15.1	12.3	10.9
BR			39.6	35.5	38.3	36.9
DR			18.6	14.5		

The median level is around 13 for male and 14 for female based on growth rate and 14 for male and 12 for female based on GRR. On the whole, a level of 13 is indicated by the data and is not far from our estimates. The fluctuations also are not much.

There are several other methods based on age data and stability of population. In the Arriaga method (Arriaga, 1968) the stable equation:

$C(x, x+4) = b \exp(-r(x+2.5))\ L(x, x+4)$, where $C(x, x+4)$ denotes population aged x to x+4, b is the birth and r the growth rate and $L(x, x+4)$ is the life table population aged x to x+4, is rewritten as

$\log_o\{C(x, x+4)/L(x, x+4)\} = \log_o b - r(x+2.5) = k+mx$, where $m = -r$ and $k = \log_o b - 2.5r$.

This linear equation connecting the natural log of the ratio of population in an age group to the life table population is solved by the method of least squares by taking various life table values till the growth rates match with known value. This would fix the life table and birth rate. Applying this method to Lesotho 1976 data, the male and female growth rates came out as respectively 2.4 per cent and 2.2 per cent with level 12.A higher level would increase the growth rates. Age reporting errors, omissions etc. would affect the results.

In the Coale-Hoover method (Coale and Hoover, 1958), the stable equation is written as:

$C(x, x+4) \exp(x+2.5)r = b\ L(x, x+4)$, or equivalently,

$C(x, x+4) \exp(x+2.5)$ is proportional to $L(x, x+4)$.

Thus with a given age distribution and growth rate, the proportional values of L(x, x+4) from x=5 onwards are calculated. The method then is to obtain e_{10}, the expectation of life at age 10 which is equal to T_{10}/l_{10} where

T_{10} = L(10,14) + L(15,19) + ... and l_{10} is approximately (1/20) {L(5,9)+L(10,14)}

The relation between l_{10} and e_0 can then be used to estimate the life expectation at birth and mortality level. The 1976 age sex data of Lesotho with growth rate of 2.1 per cent produced a male level slightly higher than 10 and a female level higher than 12 with an average near 11. The result is thus similar to the one based on Arriaga method. The lower level indicated by this method is due to the predominance of l_{10} in the value of e_{10} which in turn determines e_0 and the level of mortality. The usual inflation of the age group 5-9 and sometimes 10-14 increases l_{10} and decreases e_{10}, e_0 and mortality level.

In yet another method which is based on a technique proposed by Stelnitz (1956) the stable model equation is written as

$$\frac{C(x+5,x+9)}{C(x,x+4)} \exp(5r) = \frac{L(x+5,x+9)}{L(x,x+4)} \quad \text{so that}$$

$$L(x+5,x+9) = \exp(5r) \frac{C(x+5,x+9)}{C(x,x+4)} L(x,x+4).$$

Assuming L(0,4) = k, we can relate all the other L(x,x+4) values to k and thus T_0 of the life table can be obtained as a function of k. After obtain T_0 for the observed data for a given growth rate, we can use a trial and error method to find out which model life table would match with this.

For the 1976 data from Lesotho, a growth rate of 2.1 per cent with the above method produced a male level slightly higher than 14 and a female level of 17. Age shifting and digit preference errors affected the derived levels. To avoid some of these errors, we can modify the method to include two unknowns k and m corresponding respectively to L(0,4) and L(5,9) and consider two types of ratios with digits 0-4 and 5-9 respectively.

There are several other methods of using age sex data like these due to Brass, Carrier-Hobcraft, etc. but these are mostly for deriving vital parameters than for data evaluation and hence will not be discussed.

SOME METHODS OF AGE SEX DATA ADJUSTMENT

Based on the findings of the evaluation of the data, before it can be utilised for projection and other analytical purposes, it is necessary to adjust and smooth the data to remove some of the inherent errors, biases, deficiencies etc. However, the adjusted data should not only be smooth, it should also be consistent with the demographic, socio-economic realities in the past. Thus consistency with the various demographic parameters should be vouchsafed and not sacrificed at the altar of so called smoothness of data. Also, the adjustment should be minimal and be specific to take care of the types, varieties and magnitudes of the errors and deficiencies.

There are several methods of achieving smoothness in data. Mathematical methods are the easiest and need only very little information and can be carried through mechanically. But, one should be cautious in such simplistic models submerging some of the peculiarities inherent in the data. Moreover, the types and magnitudes of errors and biases may not be the same or even similar from one age to next or between sexes or even over time. Thus one mathematical formula might compromise some of the specialities. The other alternative is the demographic techniques - borrowing from other experiences, models etc. A combination of demographic and mathematical methods works well in many situations.

ALGEBRAIC (MATHEMATICAL) METHODS

Graphical methods or free hand drawing and the use of mechanical aids such as a French curve or a spline and weights might be tried, but the subjective nature of those should be borne in mind while interpreting the results. The oblique axis method of Carrier (1959) seems useful in many cases.

Mathematical curves, high order polynomials, Gompertz, Makeham or other special types of curves etc. are sometimes used to fit reported data.

Graduation formulae like those proposed by the United Nations or a three point verison of it, moving averages, Carrier-Farrag ratio method, Newtons halfing (quadratic interpolation) formula, esculatory interpolation formulae etc. are some of the other mathematical tools in data adjustment.

A combination of appropriate grouping, preliminary smoothing and esculatory interpolation might work in many cases. It is advisable to carry out most of these methods before deciding on the most appropriate smoothing. On the whole, these methods are risky and will have to be used with care and monitored thoroughly..

DEMOGRAPHIC METHODS

Under this category there are a whole host of methods. The best known is the one based on models or analogies. In the former, the age sex distribution of the country is assumed to fit in with an appropriate model population based on demographic parameters and other informations. In addition to the Ceale-Demeny four families, we have the Brass two and three parameter families, the recently introduced four parameter families, the Lederman systems etc. Sometimes, the age sex distribution is borrowed from the experience of another country (analogy) which is anticipated to have similar demographic evolution but has better quality data.

A combination of mathematical and demographic methods is sometimes preferable. For example, for the younger ages, the adjustments may be based on models, whereas for the other ages, a moving average or other smoothing techniques might be sufficient.

One such method which looks worth trying is that based on Brass logit system. In this method, the smoothing is carried out by fitting a linear equation connecting the observed and standard cumulated distributions through the logit transformation. For instance if Y_x and Y_{xs} denote the logits of the observed and standard cumulated age distributions, then the relationship:

$Y_x = A + B\ Y_{xs}$ can be utilised to estimate the constants A and B. The method of group averages is recommended, in view of extreme observations and variations. The standard used can be from the Coale-Demeny families, the Brass or other systems. For Sub-Saharan African countries either the North or Brass African standard is recommended whereas for North African countries, the South model seems to fit well. In countries where mortality has fallen to very low levels, the West or Brass General standard might be better.

As an illustration, we present below the reported and adjusted age sex data for Lesotho. The standard used was the north stable population with level 13 and GRR=2.5 (table 14).

Table 14 - Reported and adjusted age distribution by sex, Lesotho - 1976

Age	Male		Female		Age	Male		Female	
	R	A	R	A		R	A	R	A
0- 4	14.6	16.0	13.7	15.3	40-44	5.3	4.9	5.2	5.0
5- 9	13.4	12.9	12.4	12.3	45-49	4.0	4.2	3.8	4.4
10-14	13.2	11.2	12.5	10.7	50-54	3.3	3.5	3.3	3.8
15-19	10.2	9.8	10.7	9.5	55-59	3.5	2.9	3.5	3.2
20-24	8.4	8.6	8.9	8.4	60-64	2.1	2.3	2.5	2.6
25-29	7.1	7.5	6.8	7.4	65-69	1.5	1.7	1.8	2.1
30-34	5.6	6.5	5.5	6.5	70+	2.6	2.3	4.6	3.0
35-39	5.2	5.7	4.8	5.8					

R = Reported; A = Adjusted.

EVALUATION OF OTHER TYPES OF DATA AND ASPECTS IN A CENSUS

The age and sex data from censuses have been considered in the preceding sections. Even though these are the basic information collected in a census, there are several other demographic and socio-economic data obtained through a census. Age sex errors vitiate some of these, and conversely, questions on the detailed socio-economic information might affect age sex data and coverage of population, as already illustrated in earlier sections. Some of the errors and deficiencies in such data and how to detect them and prevent their occurences are discussed briefly below.

MARITAL STATUS AND FERTILITY

In predominantly polygamous societies, there should be parity among married males and females, unless migration is selective. Large differences would raise doubts on civil status reports. The mean age at marriage (first marriage) would give ideas of age reporting errors; so also would the mean age of fertility schedule, and mean age at loss of spouses.

Fertility data is usually riddled with underreporting and age misstatements. Brass P/F method usually can be used to evaluate and adjust data. It is advisable to collect fertility data by sex of birth, because of possibility of biases. Parity progression is a useful evaluation tool, especially in view of recall lapse problems.

In addition to coding, punching and other errors resulting in high parities at young ages, it is reported in Kenya that "such over-reporting could arise if there was a tendency to attribute to the women concerned children born to their husbands by other wives" (Kenya, 1969). Similar error is suspected in the 1973 census of Sudan.

MORTALITY

Direct information on mortality through question on number of deaths in a household has not been successful in most census type enquiries. Indirect information like child, parent, sibling, or spouse survival seem to fare better. In addition to enquiring about sex of children, age at death and parity of children etc., it is important that problems of foster children, parents, remarriage etc. are kept in view. Brass, Sullivan and Trussel methods for child survival have produced reasonable estimates of child mortality with African data, but the Preston-Palleny method is yet to be tried and is anticipated to be faced with problem of age estimation at death of children. In the orphanhood widewhood methods the problem of mean age of childbearing of males might be problematic.

MIGRATION

The usual question on place of birth, even though simple to comprehend might bring in response error through ignorance or deliberate misstatements. Since the head usually reports for everyone in the household, ignorance or place of birth of wife and relatives could easily occur. Deliberate misreporting occurs especially for foreign born (Sudan, 1980). The question on rural-urban nature of place birth results in confusion-whether it pertains to the status at time of birth or at census time. In case of duration of residence in place of enumeration, it is imperative that non-movers be excluded, as otherwise their age may be entered as duration and might create problems as noted in the 1976 Lesotho data.

SOME GENERAL OBSERVATIONS ON DATA EVALUATION

ECA (1973) in their report on the Seminar on Evaluation of Demographic Data held in Accra stressed that (i) data collection remains the fundamental aspect of research and one should always aim at improving it (ii) methods and techniques of analysis would in fact be deterimental if they were to give the impression that improvement of data collection is not necessary and (iii) these methods and techniques would be harmful if they were used as a pretext to ignore the importance of a deep quantitative knowledge of a population's characteristics, geography, economic life, sociology, customs and history.

This does not imply that data need not be adjusted, but what is needed is that in every case, adjustments should be specific to the types, varieties and magnitudes of errors and deficiencies detected and caution is needed in regard to over-correction. In other words, safe guards are needed to see that the so called 'corrected data' do not in fact, lead further away from reality. Prevention is better than cure and any amount of care and caution exercised in data collection and processing is worth the effort. Data correction cannot compensate for slackness and negligence in data collection.

A battery of tests and methods are needed before an assessment of data quality and quantity can be made. A cafeteria approach subjecting the data to several types of scrutiny might reveal the types and magnitudes of errors and biases and one may arrive at plausible explanations for these, so that further data collection efforts could be aware of these and avoid them.

The types and varieties of errors etc. vary from one country to another and perhaps over time. Generalisations from one experience is risky. Evaluation is still an art and there is the need for a lot of experience in handling data. In developing countries with many unknown facts about population, evaluation is like completing a jig-saw puzzle with some pieces missing and others distorted. What one tries to attain is to disentangle the pieces and see what emerges.

Finally, the analyst - data evaluater - should be a person with knowledge of local conditions and exposed to various types of data and situation and preferably be associated as early as feasible with the data production. Evaluation and analyses should be planned in advance and should not be an afterthought. A post mortem examination might not reveal significant factors and facts and much of the vital information collected might become either less valuable or sometimes useless.

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EVALUATION ANALYTIQUE DE LA QUALITE DES DONNEES DES RECENSEMENTS- QUELQUES EXPERIENCES AFRICAINES

R E S U M E

L'évaluation ou l'estimation de la qualité des données est une partie intégrante important du recensement. Etant donné le grand nombre d'enquêteurs recrutés temporairement pour la gigantesque opération qu'est le recensement de la population tout entière (et dans les pays en développement dont une bonne partie des habitants sont illetrés, ignorants et superstitieux) et le manque de temps pour approfondir les réponses, il est tout à fait naturel que les données rassemblées soient sujettes à divers types d'erreurs dont l'importance varie.

Il importe de rechercher et de corriger les erreurs de couverture tout comme les erreurs de contenu, si l'on veut utiliser les données dans la planification, l'élaboration des politiques et la mise en oeuvre des programmes. En Afrique où la planification tend de plus en plus à concerner les divers couches de la population, les données utilisées doivent incontestablement être d'assez bonne qualité. On s'efforce par des évaluations d'examiner minutieusement les données et d'indiquer les lacunes et les inconvénients qu'elles présentent afin de procéder à des ajustements et à des corrections. A titre accessoire, ces évaluations aboutissent maintes fois à des paramètres démographiques qu'on ne peut probablement pas obtenir autrement, étant donné le caractère insuffisant ou incomplet des statistiques de l'état civil.

Les méthodes directes et indirectes sont toutes utiles dans le processus de l'évaluation de la qualité des données. Cependant peu de pays de la région ont tenté d'effectuer des enquêtes post censitaires pour estimer la qualité des données, ce qui rend indispensable les recours aux techniques indirectes dans l'estimation de la qualité des données. De nombreux instruments d'analyse ont été mis au point pour évaluer la qualité des données et déduire des paramètres démographiques. Les erreurs variant à maints égards d'un pays à l'autre et peut-être dans le temps, l'innovation et l'adaptation en matière de techniques se poursuivent constamment afin de permettre de mieux saisir les données.

La présente étude récapitule quelques expériences africaines d'évaluation analytique des données, expériences découlant du dernier recensement de certains pays africains en particulier. Les cas qui ont retenu l'attention sont ceux du Ghana, du Lesotho, du Libéria, de la Libye et du Soudan où l'auteur a contribué à l'évaluation et à l'analyse des données.

L'évaluation de la qualité des données étant toujours un art, il est recommandé d'appliquer une variété de techniques à ces données avant de tirer des conclusions. Les critères de concordances semblent utiles pour arriver à des conclusions sur la qualité et la quantité des données. Un point à souligner est que la correction des données ne saurait se substituer au soin et à la prudence à apporter dans la collecte des données et les ajustements et corrections doivent être non seulement réduits au minimum mais aussi pertinents.

Il est avantageux de disposer d'analsstes ayant une grande expérience et une vaste connaissance de la situation socio-économique de pays concerné et participant depuis le tout début à la production de données dans le pays.

Enfin, il est recommandé d'envisager les évaluations et les analyses à l'avance. Un examen après coup ne révélerait probablement pas de paramètres et de faits significatifs et aura moins d'utilité et moins d'efficacité.

SOURCES OF COVERAGE AND CONTENT ERRORS IN POPULATION AND HOUSING CENSUSES

INTRODUCTION

Population and housing censuses are extensive and complex statistical operations which involve vast numbers of people at their various phases. It is therefore not surprising that the assertion is made that the figures of censuses however carefully taken cannot be relied upon as being absolutely accurate.

Some inaccuracies in census figures may be due to the deliberate exclusion of sections of the population from the counts. Such exclusions may come about as a result of the type of census being undertaken, i.e., de facto or de jure. Other sections of the population may be excluded because it is not feasible to include them. The reason may be related to cost considerations, danger to census personnel, national security, etc.

Other inaccuracies may occur not by design of the census organizers. It is this type of inaccuracies which are considered errors in census counts, and they occur in varying degrees in counting any sizeable population. However attempts to measure accuracy of census counts are a relatively modern development. It is now accepted that "good census practice requires a careful consideration of the completeness and accuracy of the census results" (UN, 1970).

Errors in censuses may be divided into two types, namely, errors in coverage and errors in content. Coverage error refers to the gap between the true population figure and the census figure. In general, coverage error may occur because of failure to cover certain areas/localities and/or houses and/or households and/or individuals. Such omissions result in under-enumeration. Where the error is due to double counting of any or all of the above categories, there will be over-enumeration. On the other hand, errors in content refer to mistakes in the reporting or recording of information concerning the characteristics of households or individuals. Several sources of both type of errors can be distinguished. This paper will attempt a survey of the sources of both coverage and content errors in population and housing censuses.

Sources of coverage error

Sources of coverage error may be classified into four main categories. These are: errors attributable to faulty design of the census; poor enumerator performance (poor quality enumerators); difficulty in the enumeration of certain areas and/or persons; and loss of records.

Faults in design of census

Census activities may be grouped into three broad phases. These are pre-enumeration, enumeration and post-enumeration phases. The pre-enumeration phase consists of all the activities undertaken in preparation for the actual count. One of the principal activities of the pre-enumeration phase involves the preparation of a plan to ensure that all parts of the territory or country will be covered during the enumeration phase.

The plan may involve the division of the country into enumeration areas and the preparation of enumeration area maps which will be used by enumerators to assure proper coverage. Alternatively a list of localities or other such administrative units may be used. In the African situation, EA maps or list of localities or a combination of both have been used in censuses.

Either procedure is a potential source of coverage error. Poor a census mapping programme may lead to the creation of no-man's-land or the overlapping of enumeration area boundaries. Such situations result in undercount and overcount respectively during census enumeration.

The use of list of administrative units presents even greater problems since such lists are usually incomplete particularly in countries with a large, rural, dispersed sector. In some instances villages may have identical names or a village may be known by two different names. Only careful planning which includes pretesting will reveal such situations and allow proper measures to be developed to eliminate or diminish such sources of error.

The enumeration phase involves the procedures by which information is obtained from the population. The persons for whom information will be required may be determined according to the place of usual residence - de jure count - or according to where the individual spent the census night - de facto count.

The de jure count provides more useful information for many purposes but in many African countries the concept has proved difficult in its application in the field. Improper or careless application of the concept may result in missing some persons or in double counting others. Omission of persons occur particularly in the case of persons who are temporarily away from home during census enumeration.

The de facto concept avoids definition problems since generally there is little room for doubt as to where a person spent the census night. However if the enumeration extends over a considerable period people tend to forget some of those who spent census night in the house, or they may include persons who did not but are present at the time of the interview.

Only careful planning which includes pretesting of concepts to determine their feasibility in the census situation and the adoption of appropriate measures will minimise this source of potential coverage error.

Another related issue is the method of enumeration adopted. It must be pointed out that no method can guarantee error-free coverage but a well-designed census programme which takes into consideration the circumstances of the country will reduce the error from the source.

Methods of enumeration may be broadly divided as follows: Canvasser method; self-enumeration and the group-assembly method. All the three methods in varying forms have been used in African censuses. The canvasser method employs trained enumerators in house-to house visits to interview heads of households and/or individuals directly. If proper control is exercised in assigning areas to enumerators the canvasser method has great

potential in assuring good coverage. Self-enumeration involves the distribution of questionnaires to respondents for completion. The distribution is effected by mail or through house visits by interviewers. This method is feasible in a country with high literate population. Also if the distribution will be by mail then the postal system should be well developed. Only a few African countries have adopted this method for sections of their populations in their censuses. The use of the method has involved follow-up visits by interviewers, to reduce the size of non-response which otherwise may be quite large.

The group-assembly method was in common use in several countries during the pre-modern census period. This method has now generally been discarded though at least one country in the African region is known to have adopted the method in enumerating the rural, dispersed sector of the population in its recent population census. The method may involve the use of village or community headmen to assemble the people in a central location for purposes of enumeration or alternatively the headman may give information concerning the people in the village or community. Since boundaries of areas are often poorly defined and in some cases may be in dispute, the group assembly method greatly increases the potential for omission or duplication of area and population.

The post-enumeration activities, namely receipt of documents from the field, manual and machine processing of the data. evaluation, analysis and publication of results constitute the final phase of the census programme. The process of transmitting documents to the central office and the processing of the census returns are also potential sources of coverage error but such errors occur through poor operational control system resulting in loss or duplication of records.

Poor enumerator performance

Another element closely associated with the enumeration phase of the census programme is the quality and performance of the enumerators. However well-designed the census programme may be errors in coverage may be introduced by the enumerators in the application of the procedures through carelessness, lack of understanding of the concepts and procedures or poor interviewing techniques or a combination of all three.

During census enumeration, a pre-requisite for good coverage is proper identification of the boundaries of enumeration areas. Failure on the part of any enumerator to identify and cover only the area allocated may lead to undercount or overcount.

Even when each enumerator has correctly identified his/her enumeration area and enumeration has been confined to areas assigned to each, errors in coverage could occur if houses/compounds and group quarters are not covered systematically. This type of error is more likely to occur in several African countries, particularly in some rural parts and urban squatter areas, where streets are not named nor houses numbered. In such instances there is a great likelihood of undercount through the omission of some houses/compounds/group quarters.

The enumerator factor in coverage error occurs also through the failure or inability on the part of enumerators to grasp fully the concepts. This happens particularly with regards to the identification of persons to be included in the count. Difficulty or carelessness in the use of the de jure concept has already been mentioned in paragraph 11.

A related example is the enumerator's inability to apply the reference period properly. For example, one or more enumerators may fail to include persons eligible for inclusion in a count but who either died or changed their residence since the reference period. Conversely, persons who became residents after the reference period may be included. This source of error is also encountered quite often in respect of items on economic characteristics where enumerators often fail to restrict the questions on employment to the required reference period. Thus an inflated or deflated number of persons in a particular category, such as the employed, is obtained.

A proper understanding of the concepts is therefore essential for good coverage but it is not enough. Enumerators need to be well groomed in the art of interviewing. They should be able to establish rapport with respondents in order to obtain the necessary information. For instance, in addition to asking the questions on the census questionnaire, in certain instances enumerators have to probe in order to obtain information regarding persons not present during the period of interview. Failure to do this may lead to the omission of households within houses or some individual members of households particularly infants (deceased/living) and the aged.

Another source of coverage error attributable to the quality of enumerator performance is fictitious enumeration. Errors from this source occur as a result of poor supervision, lack of dedication on the part of enumerators or outright criminal intent.

Poor supervision during enumeration may tempt some enumerators to complete questionnaires for persons supposed to inhabit certain localities without actually visiting the areas concerned. Since the information is based on guess work, there might be either under-count or over-count. In other instances, enumerators may, for one reason or the other, deliberately inflate the census figures through enumeration of non-existent persons.

Places and persons difficult to enumerate

The size of coverage error is also closely related to the degree of difficulty in canvassing the various parts and population categories of a country.

For instance, the temptation for enumerators to resort to fictitious enumeration is greatest in respect of remote areas and dwellings. However, if even the temptation is overcome the probability of such areas being missed in census counts is quite high; hence such areas constitute a major source of coverage error unless, as stated earlier, the census organizers decide to exclude such areas from the census enumeration. When such strategy is adopted the census figures will be known to refer to a well-defined delimited territory of a country.

A related source of coverage error is the population group which spend a greater part of their time outside their places of residence. Such persons/households are usually not at home when enumerators make their rounds. In such cases enumerators are usually expected to make callbacks or where possible interview such persons at their places of work. If, however, enumerators fail to honour callbacks or are unable to obtain accurate information on the number of persons who spent the census night in the relevant housing units from neighbours after repeated callbacks, then some persons in the "not-at-home" category of the population will be missed.

Similarly the unstable and semi-stable population require special arrangements for their coverage. If the census organizers fail to make adequate preparations for the enumeration of persons in those categories then a sizeable number of them may be missed.

Loss of records

The preceding discussion has attempted an identification of sources of coverage error at the pre-enumeration and enumeration phases of census operations. At the post-enumeration phase loss of records and duplication of information on individuals constitute the major sources of coverage error. The loss and erroneous duplication of information may occur during the processing of census returns in the field and/or office as a result of improper control system.

Failure to account for all completed census questionnaires during despatch of documents from the field to the census head office as well as loss of records during the movement of documents between processing sections, if undetected and corrective measures taken, will result in an undercount of the total population.

Conversely, lack of strict control during keying of the census returns may lead to duplication of information on individuals and thus an inflated total census population figure.

SOURCES OF CONTENT ERROR

Sources of content error may be classified into three main categories. These are: errors arising from concepts and enumeration procedures; errors introduced by enumerators and errors made during the processing of the census returns

Errors arising from concepts/enumeration procedures

Errors in census data from this source occur in several ways. These include recall lapse, ignorance and/or lack of experience on the part of respondents and/or enumerators, wording of questions and method of recording answers on questionnaires and proxy interviewing.

Some of the topics investigated in censuses require respondents to recall past activities. Such topics include respondents' past economic activities or migration history. Respondents may fail to recall the details of such past activities accurately and thus introduce errors into the census data.

Respondents may also not have adequate knowledge of some of the topics being investigated. They may however give responses to questions being asked to hide their ignorance, or to please the enumerator or just to get over with the interview as quickly as possible. Such instances are potential sources of error in respect of the topics being investigated, particularly if the enumerators are not experienced enough to handle the situation properly.

An example of instances where respondent's ignorance reinforced by poor enumerator performance may have adverse effect on the quality of census information is in respect of respondent's age. Even in cases where respondents may have some idea about their ages there is a tendency in many countries, particularly in many African censuses to report their ages in years ending in zero and five. Thus data on age in many African censuses have tended to be of poor quality.

Errors in census data may also be attributable to the method of enumeration particularly the wording of questions and the method adopted for recording answers. Some census questionnaires do not contain the exact wording of the questions which enumerators should ask in order to obtain the required information. Instead of a question, the item is listed and the enumerator has to elicit the desired information through his own ingenuity. For example, instead of "what is the highest level of school ... completed" only "Education" or "Educational attainment" is listed on the questionnaire. The practice may not pose much problem for some simple items but for others, just listing the topics will save space but at the expense of the accuracy of the data.

A related issue which may also be a source of error in census data is the situation in which the language of the questionnaire is different from the language in which the interview is conducted. This is the case in many African countries where the language of the census questionnaire is English or French but the interview is conducted in one of the many local languages. Unfortunately, the language problem is not given the seriousness it deserves by some African census organizers. Enumerators are left to translate the census questions as best they could and since the quality of enumerators varies widely errors in translation of some questions are likely to arise.

The method adopted for recording asnwers during census enumeration may also affect the accuracy of the census data. It is therefore essential that careful consideration be given to the technique to be adopted. One technique which may increase the chance for error in recording answers is the one in which enumerators enter only codes on the census questionnaire. The enumerator is provided with a list of acceptable responses with their respective codes. During the enumeration the enumerator determines the appropriate code for a given response and records only the code on the questionnaire. This practice may save questionnaire space and speed up processing by eliminating post-enumeration coding but the procedure gives an additional responsibility to the enumerator who often has to work under very difficult conditions as compared with office workers. Further, compared with coders, very little control, if any, can be exercised over enumerators during the period of interview and their errors are more difficult, and sometimes impossible, to correct.

Census data accuracy may also be adversely affected by proxy interviewing. During census enumeration the usual procedure is for the head of household or some responsible adult household member to supply the required information for the entire household. In some other instances neighbours may be asked to supply information on other households if enumerators fail to contact such households after a number of callbacks. The procedure of proxy interviewing saves time and cost but it is a possible source of error in census data.

Errors introduced by enumerators

The enumerator effect in coverage error has been mentioned in an earlier section. Also the contribution of enumerators to content error has been referred to partly in the preceding section - errors attributable to concepts and enumeration procedures. Enumerators may also introduce errors in census data irrespective of the concepts or enumeration procedures adopted. The ways in which the errors arise include deliberate inclusion of erroneous information (mainly through fictitious enumeration), poor enumerator performance which may involve wrong questions being asked or erroneous interpretation of questions or carelessness in recording entries. Also an enumerator may change a respondent's answer to conform with the enumerator's own perception of the respondent's social status.

Data processing errors

The quality of census data may also be affected by errors made during the data processing phase of census operations. Such errors include those made during coding which are undetected during verification of coding as well as errors introduced by verifiers in their attempt at correcting coding errors. Other errors introduced at the data processing stage arise from wrong keying of data and poor quality programming at the tabulation stage. Finally imputation procedures to rectify missing entries or unacceptable information on census returns may also affect the accuracy of census data.

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SOURCE DES ERREURS DE COUVERTURE ET DE CONTENU DANS LES RECENSEMENTS DE LA POPULATION

RESUME

Les erreurs dans les recensements se divisent généralement en deux catégories principales. L'erreur de couverture est la différence entre le "Vrai" chiffre de la population et le chiffre donné par le recensement. De telles erreurs peuvent découler d'une couverture insuffisante de certaines zones, localités, maisons et ou de certains ménages ou individus. Par ailleurs, les erreurs de contenu concernent les fautes dans la déclaration ou l'enregistrement d'informations relatives aux caractéristiques des ménages ou des individus faisant l'objet du dénombrement. On peut distinguer plusieurs causes d'erreurs de couverture et de contenu.

Les causes des erreurs de couverture peuvent se classer en quatre grandes catégories. Il s'agit d'erreurs imputables à un plan défectueux du recensement, au travail médiocre des enquêteurs (c'est-à-dire avec des enquêteurs de piètre qualité), à des difficultés de dénombrement de certaines zones et/ou de certaines personnes et à la perte de documents concernant certains districts ou certains individus.

Les sources des erreurs de contenu sont essentiellement de trois sortes. Il y a les erreurs provenant des concepts et des méthodes de dénombrement, celles faites par les enquêteurs et celles faites au cours du traitement des résultats du recensement.

Les erreurs dues aux concepts et aux méthodes de dénombrement comprennent les défaillances de mémoire ou proviennent de l'ignorance et/ou du manque d'expérience des enquêtés et/ou des enquêteurs, du libellé des questions et la méthode d'enregistrement des réponses aux questionnaires ainsi que les interrogatoires par procuration.

L'influence de l'enquêteur dans l'erreur de contenu peut s'exercer par l'incorporation délibérée d'informations erronées (essentiellement par l'intermédiaire d'un dénombrement fictif) et/ou d'interrogatoires médiocres.

Enfin, les erreurs faites par les codeurs, les vérificateurs et les opérateurs lors du traitement des données du recensement peuvent avoir des répercussions négatives sur la qualité des données des recensements et accroître ainsi l'importance des erreurs de contenu.

TECHNIQUES OF COVERAGE ERROR EVALUATION

INTRODUCTION

A population census, like other statistical data collection operations, is not free from errors. Given the large-scale nature of a census operation, involving a series of integrated steps, such as mapping, questionnaire design, enumeration, coding and data processing, the possibility exists for errors to enter the collected information at each of these phases. This may occur because of a host of reasons such as poor mapping work, poor questionnaire design, inadequate attention paid to the training of the field staff and some of the respondents being ignorant about answers to some questions. (UN, 1957)

The resultant errors can take various forms - errors due to inadequate preparation; errors of non-response; errors of ascertainment or observation; processing errors; errors in constructing estimates; errors in interpretation; and errors in publication. (Som 1971:21)

For analytical purposes, we can classify these errors into two categories, namely:

(a) coverage and
(b) content errors

Coverage errors are errors that affect the returns on the total count of persons or housing units. This could come about because of omission of persons or housing units that should be enumerated, resulting in under-enumeration; or erroneously counting a set of persons or housing units more than once, leading to over-enumeration.

Content errors are errors pertaining to the characteristics of persons or housing units reported in a census. This type of error may occur because of the provision and/or recording of incorrect answers to the questions. It may also come about because interviewers inadvertently or deliberately fail to put to the respondents some of the questions. A classic case of content error in African censuses relates to age (Van de Walle, 1968: 143-150 and ECA Population Division, 1981). It has been observed that the returns on age from African censuses are of poor quality largely because the majority of the population are not aware of their ages in numerical terms.

A population census and sample survey evaluation programme attempts to delineate the two types of errors, with a view to alerting survey statisticians and users of the limitations of the data published. Another reason for such exercises is based on the argument that "a survey (or a census) in which the magnitude and direction of different types of errors are not evaluated, or at least indicated, may give a false sense of accuracy in the collected data". (Som 1971:27)

This present study is concerned with the description of techniques, especially those relevant in African countries, for the evaluation of coverage error. 1/ A variety of methods exists for classifying the techniques used in the evaluation of coverage error. For the purpose of this paper, we shall classify them in two groups -

(a) methods of direct checking and
(b) methods of checking internal and external consistency of the collected data.

METHODS OF DIRECT CHECKING

The main feature of this method is the comparison of individual records from the census returns with records from another data collection system, usually a sample survey.

The post enumeration or re-enumeration survey (PES) is the principal method for the direct evaluation of the coverage of population and housing censuses. The PES involves a replication of the census enumeration in selected enumeration areas, chosen by means of probability sampling. Records from the census are matched with those from the PES. The case-by-case matching and field reconciliation procedures of this method can pinpoint areas of errors and distinguish those attributable to under-enumeration from those based on over-enumeration: "This ability to identify the component of error provides the basis for an understanding of the reasons for coverage error and thus gives clues to methods of reducing coverage errors in future censuses". (Siegel, 1973)

In the traditional PES, emphasis is placed on doing a better enumeration job in the re-enumeration survey than in the census. To achieve this objecti e better trained and educated enumerators are employed than those used in the census and meticulous attention is paid to other quality control checks. In this way the PES can be used as the standard against which the census coverage rate could be assessed.

Specifically, from the matching, an idea of under-enumeration is derived from the extent by which individuals, housholds and housing units recorded in the PES fail to be identified in the census returns; and over-enumeration, by the extent these items are located more than once.

The amount of items matched between the census and the PES can be employed as a correction factor (cr):-

$$cr = S/M$$

where S = the total number of persons or households or housing units enumerated or listed in the PES; and

M = the total number of persons or households or housing units enumerated in the PES for whom/which corresponding census records were found.

The traditional type PES has been tried in the majority of African countries. The major problems encountered in its implementation are matching and improper preparation. 2/ Matching problems have arisen because of the vagueness of addresses and similarity of names in many African countries.

The other type of PES uses the dual record system as a model. It also involves mounting of a survey to evaluate the census and a case-by-case matching of the records from the census with those from the survey. In addition, this approach to census evaluation emphasises independence of the two data collection systems i.e., the census and the PES.

To estimate the completeness rate, a case-by-case matching of the reported events by the two systems is undertaken in order to discover those events reported by both systems (M), those reported by the census but missed by the PES (N_1) and those recorded in the PES but missed by the census (N_2). From the values of these various components, an estimate of the completeness of reporting for the census or the PES or both can be estimated. (Chandrasekaran and Deming, 1949).

Liberia tried this type of PES for the evaluation of the 1974 population census of Liberia (Marks and Rumford 1978). Such problems as the very short questionnaire form used, which made matching complicated, difficulties to enumerate the transient population and those without usual places of residence and a compromise of the condition of independence in some of the sample EAs resulted in this experiment not providing unambiguous answers about census coverage rates.

METHODS OF CHECKING INTERNAL AND EXTERNAL CONSISTENCIES

Consistency checks involve testing for the plausibility of the census coverage by asking such questions as whether the collected data are within acceptable limits and whether the distribution of the population components are reasonable. The technique of evaluation, performed usually at the aggregate level, consists of the comparison of totals and sub-totals of the census population with information from other sources for plausibility.

The demographic analytical technique is one example of this approach. By this method, expected totals of the census are estimated from independent demographic data sources. The independent data sources may include past population censuses, births and deaths data from civil registration systems and migration statistics from frontier administrative records.

For example, from the balancing equation the expected totals of the census can be calculated - i.e.,

$$P_{t+n} = P_t + {}_nB_t - {}_nD_t + {}_nNM_t$$

where

$P_{t=n}$ = the enumerated population at time t = n i.e., expected total of present census

P_t = = the enumerated population at time t

nBt = the births occurring between time t and time t + n

nDt = the deaths occurring between time t and time t + n, and

nNM = the net migration (in-migration minus out-migration) between t and time t + n

The balancing equation method for the evaluation of censuses is hardly used by any African country for obvious reasons: the registration of births and deaths is incomplete in the majority of the countries.

When the country has the results of at least two good censuses, data sources a number of African countries now possess, the evaluation of census coverage can draw on other techniques. A popularly used method has been the comparison of intercensal growth rates. The justifications for the use of this method are that population growth occurs in a gradual manner and that there are predictable levels within which normal growth falls. (UN, 1957:10)

In addition to the growth rate of the total population, growth rates of the rural/urban and indigenous/non-indigenous populations are also sometimes compared in order to throw light on under- and/or over-enumeration.

Alternatively, census totals have frequently been compared with data from independent non-demographic sources such as school attendance records, tax lists and electoral registers. The assumption of the comparison is that when there is close agreement between the census and the data from the independent sources, confidence can be placed on the results of the census, and vice versa, when the converse is the case.

The comparison of the independent records and the census is sometimes confronted with problems because of differences in the time reference, and in the concepts, definitions and classifications.

Information on household size structure in various parts of the country, such as urban and rural, derived from say a previous census or a sample survey can also be used to evaluate the census head counts. If for example in a recent national household survey it was established that average household sizes in urban areas were higher than in rural areas, yet the opposite finding was derived from the census, there will be a need to do more thorough investigation about coverage in the census.

The interpretation of the various evaluation tests on coverage ought to benefit from other information about the country, such as the geographical location of industry, the typology, the spatial spread of urban localities, etc. From the information from these sources a priori knowledge about the distribution of population among regions can be roughly ascertained. Therefore if the census comes out with a lower population figure for an area that is supposed to have a higher population, it would be necessary to subject the data to further examination.

As the over and/or under-enumeration rates of the census affect certain components of the population, for example, young children, girls under or above the age of puberty, young males in their teens, disproportionately, evaluation programmes pay special attention to these groups. In so far as this topic is treated in detail in another paper, we shall here only briefly discuss the evaluation methods. (ECA, Pop. Division, 1981)

The age distribution from the census, $(\underline{x})$, is compared with those from a stable population with similar parameters, $\bar{C}_s(s)$: The census cumulative age distribution, say for the age group C(0 - 4) is compared with cumulative age distribution of the stable population, $\bar{C}_s$ (0 - 4) (UN, 1967). The deviations from the stable age distribution are taken as estimates of under or over-enumeration.

This approach was used for an examination of a selected number of female age distributions from African censuses and surveys (and also from India, Indonesia and Pakistan). The following patterns of coverage errors were discovered from the study: a surplus at 5-9, a deficit in the class 10-14 and 15-19 and a surplus at 25-34. (UN, 1967).

It has, however, been pointed out by Krotki (1968) that this approach does not identify the deviations from stability that are attributable to selective age under/over reporting from age misreporting.

Another approach to evaluating coverage for population age groups is by the use of census survival rates, for countries that have taken at least two good censuses. (Demeny and Shorter, 1968). Survival rates over one or with extreme values under one indicate age classes where over- and under-enumeration occur. Since this may occur because of short-comings due to misreporting, omissions etc., in any of the censuses being compared, there is the problem of appropriately assigning to either census the over and/or under-enumeration rate.

On a general level also, there are problems connected with the use of demographic and non-demographic aggregate data for the evaluation of census coverage. Sometimes, the rate of coverage of these data sources are not themselves complete enough for them to be models against which to compare the census totals. Also, the assumptions employed in the manipulation of these data sources for them to serve as standards against which the census is evaluated may not be correct. (Siegel, 1973)

The success of a census coverage evaluation programme depends to a large extent on the availability of statistical information on the country. Where there are abundant data sources - demographic and non-demographic - there are good potentials for coverage evaluation exercises to produce fairly accurate pictures of coverage under and/or over-enumeration rates. Well prepared and implemented post-enumeration or re-enumeration surveys, precisely because they provide much more information on both the patterns and causes of coverage errors, are indispensable for census coverage evaluation and their more frequent usage ought to be encouraged in African countries.

NOTES:

1. A similar discussion covering content error is the subject of another paper (ECA, Pop. Div. 1981) in this series. "Analytical techniques for content error evaluation."

2. For a detailed discussion of the shortcomings of African PES, see: "Coverage and Content Error Evaluation: Practices and Problems in African Censuses, 1960-1980", in this series; and ECA (1975).

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TECHNIQUE D'EVALUATION DES ERREURS DE COUVERTURE

R E S U M E

Dans la présente étude, les méthodes sont décrites, notamment celles valables dans les pays africains pour l'évaluation de la couverture des opérations de recensement: Ces techniques se regroupent en gros en deux catégories :

a) Méthodes de contrôle direct et;
b) Méthodes de contrôle de la concordance interne et externe des données rassemblées.

Lors de la description des méthodes permettant de vérifier directement la couverture d'un recensement, l'enquête post censitaire (EPC) a été décrite. L'EPC consiste en une répétition du dénombrement dans les districts de dénombrement déterminés choisi sur la base d'un échantillon probabiliste. Deux types d'enquête de ce genre ont été expérimentés dans les pays africains : a) le type traditionnel qui vise à mieux faire que le recensement en reconstituant le chiffre de la population du moment du recensement, et b) le type fondé sur la méthode de double collecte qui met l'accent sur l'indépendance statistique du système de collecte de données.

En rapport avec l'examen des méthodes de vérification de la concordance interne et externe, des techniques telles que la méthode de l'analyse démographique, l'équation de concordance, les applications des recensements passés de la population et d'autres données provenant de sources administratives ont été discutées.

Grâce à la méthode de l'analyse démographique, les chiffres totaux probables des recensements sont estimés à partir des statistiques démographiques obtenus indépendamment des données sur les naissances, les décès et les migrations. Pour avoir une estimation de la population au moment du recensement à la période comparable $t \pm n$, le chiffre total donné par le recensement au début de la période, temps t, est ajouté aux naissances, aux chiffres nets des migrations entre t et $t \pm n$, tandis que les décès au cours de la période entre t et $t \pm n$ sont soustraits. Etant donné que les systèmes d'état civil sont presque partout incomplets en Afrique, cette technique est à peine utile pour les pays africains

Il est également possible d'évaluer la couverture du recensement à partir d'indicateurs tels que le taux annuel moyen d'accroissement de la population dérivé des recensements passés de la population. De même, des données provenant de sources administratives telles que les documents sur les effectifs scolaires ont servi à évaluer la couverture du recensement pour un sous-ensemble de la population couvert par le recensement comme par exemple la population scolaire.

Un inconvénient de l'utilisation de ces diverses statistiques - recensements passés et données provenant des documents administratifs est qu'il n'est pas possible parfois de faire une déclaration sans équivoque au sujet du champ couvert puisque ces sources fournissent des données incomplètes et/ou précises.

STATISTICAL EVALUATION OF CONTENT ERROR

Introduction

Although coverage error evaluation has received attention in some African censuses, very little appears to have been done on the evaluation of content error except through analytical techniques. A review of the limited African experience in content error evaluation is given in the first article in this bulletin - The Coverage and content error evaluation - practices and problems in African censuses, 1960-80.

It may be recalled that even the United States with its long tradition of content error evaluation spanning over at least three decades decided for its 1980 Census of Population and Housing to limit the type and scope of its statistical evaluation of content error. The main reasons were the complexity and cost of mounting such an operation.

The main objectives of content error evaluation are two-fold. Firstly, it provides an indication of the reliability which should be attached to the published data. Secondly, by drawing attention to the defects in the data, it enables improvements to be made to the design and organization of census or survey operations in the future. With respect to the first objective, it should be noted that it is now universally accepted that producers of data should provide an indication of the reliability of the information produced. In the past, efforts had been concentrated in sample surveys in providing estimates of sampling errors which constitute only one component of the total error. However, the non-sampling errors have been found in most surveys in Africa to be more important than the sampling errors. Thus an indication of the content error helps in providing a more comprehensive picture of the total error in the census or survey. In considering the second objective one has to bear in mind that these statistical measures of reliability are not always precise but by indicating roughly the levels of reliability, the census or survey planners can concentrate their efforts in future operations on the improvement of the collection and processing of the most defective types of data identified during the evaluation process.

In the third paper in this bulletin - Sources of coverage and Content error - the different sources of content error had been identified. These sources can be summarised as follows: respondent effects, interviewer effects, general prevailing conditions, faults in planning and design and format of questionnaires, processing errors and an interaction of any of the preceding factors. To examine the techniques for the measurement of content errors it is important to understand how all these factors contribute to the error in the final tables.

It is also essential to note that it is not enough to wait till the errors have been made and then to set in motion a complex and costly operation for the measurement of the content errors. For this reason effective controls are normally established at every stage of the data collection and processing. The allocation of resources to the control of these errors is usually done in such a way as to minimise the error in the final tables. Qualtiy control of data collection and processing would normally include field and office scrutiny of questionnaires, verification and reverification of coding (dependent or independent or both), etc. At each stage some suitable acceptance or rejection rules

will be formulated usually depending on whether acceptance sampling or process control is being used. In spite of any standard control which may be established at any stage of the collection and processing errors will still be found in the final tables. The programme of content error evaluation aims at providing some measure of the size and direction of errors in these final tables.

It should also be mentioned that as part of the World Fertility Survey Research Programme a project for the study of response errors was implemented with funds made available by the Canadian International Development Research Centre. The study was intended to cover the following WFS countries: Burma, Lesotho, Peru and Turkey. However, information available in ECA suggests that the study in Burma has not yet been conducted. In the three remaining countries the main WFS survey and the re-interviews have been conducted. In Lesotho, the main survey was started in August 1977 and the re-interview commenced two months later. Peru's re-interview was conducted a month after the start of the main survey in July 1977 while that of Turkey commenced in September and was completed in November, 1978 with the main survey and re-interview being carried during the same period.

Some of the results of the response errors study was presented by Colm O'Muircheartayth and A.M. Marckwardt at the World Fertility Survey Conference in London in July 1980. It is hoped that the results of the study will help in improving the state of the art of content error evaluation.

Techniques for Content Error Evaluation

Three approaches are normally used to evaluate content error. namely: record checks, re-interviews with or without reconciliation interviews and matching of census data with independent survey results. In record checks, data obtained from the census will be matched usually individually with data from other records and inconsistencies between the two types of sources measured. In the re-interview approach an entirely new survey, usually on a sample basis, is carried out with the primary purpose of measuring discrepancies between the census data and the re-interview information. Usually more detailed questions are included in the re-interview to ensure a higher quality of responses. The third approach implies the matching of census data with an independent survey carried out about the same time as the census. The matching by the US Bureau of the Census of census data with individual information from the Current Population Survey (CPS) is a good example of this approach in content error evaluation.

It should be noted that each of the three approaches mentioned above involved different procedures as outlined in paragraphs 10-15. There is also great variation in costs. Although no figures on comparative costs are available, it is reasonable to assume that the ranking (from low to high) in relation to costs for the three approaches would be: record checks, matching with independent survey and re-interviews.

Record Checks

Not enough information is known about the procedures adopted in African censuses for the measurement of content errors. However some information is known about how these were carried out in Ghana and Gambia to cite only two examples, and these will be used to illustrate the technique. In the 1970 Census of Ghana an attempt was made to test the data on persons aged less than 12 months who were born in the locality in which they were enumerated with the birth registration records from the same locality. This was done in two towns, Axim and Winneba, to test the completeness of birth registration. In this exercise only about 40 per cent of persons stated to be aged zero (less than 12 months) on the census questionnaires could be identified on the birth registration forms. A number of reasons could account for this high discrepancy in spite of the relatively high level of birth registration completeness in the two towns. Firstly, lack of uniqueness of names and problems of identification using names of children complicated further by the fact that census records did not show whose children they were made matching difficult. Secondly, due to the practice of late registration which is deeply rooted in traditional beliefs, some of the children enumerated during the census enumeration may not have been registered at that time. Finally, erroneous information relating to age or place of birth or both may have affected the ability to locate the appropriate birth records.

The second type of record check attempted in the 1970 Population Census of Ghana was an employment record check which sought to compare individual information on occupation and industry for individuals employed in selected industrial establishments. The census questionnaire listed addresses of establishment information on an individual basis could be obtained from these establishments. Two approaches were contemplated: one was to send to the establishment the names of persons who stated that they were employed by that establishment together with their occupation and industry to enable the establishment to correct the information where necessary. This approach was abandoned during the preliminary test when it was argued that it constituted a breach of the undertaking by the census office to treat all census information as confidential. The second approach of getting selected establishments to give a list of names and residential addresses of persons in those establishment was also abandoned due to lack of co-operation of the first two establishments approached and the complex procedures this approach involved.

A third example of the use of record checks was in comparing aggregate (rather than individual) data from the census on persons stated to be attending school at that time with Ministry of Education figures. This showed that the census figure overstated the Ministry of Education figures. Unfortunately no measure of error could be obtained from this operation because the Ministry of Education figures were themselves subject to considerable error.

In the Gambia, Gibril (1979) matched records from the 1973 Census of Gambia with records from a Research study carried out by the Medical Research Council in a few villages. Since the Medical Research Council data for the selected villages spanned over a period of 22 years, this made it possible for detailed matching of the age records to be made and for some measure of inconsistencies between the two sets of data to be calculated.

Re-interviews

It is sometimes necessary to organize a special survey for content error evaluation. These surveys are usually referred to as re-interview studies. In the re-interview some of the census questions are repeated either in the identical form in which they were asked in the census or with more detailed probing questions intended to elicit more reliable responses. Tables 1 and 2 culled from the 1960 Population Census Report of Ghana Volume V show the results of such re-interviews for two basic population variables, age and birth place. The responses from the re-interviews showed that on age only 57 per cent of the population gave their ages in identical ages in both the census and the post enumeration survey. The corresponding figure for identical single ages is much lower, about 24 per cent. For the birth place data, however, the proportion was much higher. The figures were Total, 94, males 98, females 93 per cent. The US carried out a similar re-interview programme for the measurement of the accuracy of data for selected population and housing characteristics as part of the Evaluation and Research Programme of the US 1970 Census of Population and Housing. In the US survey, questions on population covered origin and descent, mother tongue, vocational training, nativity, country of birth of parents, citizenship, year of immigration, year moved into present house, number of children ever born. The selected housing characteristics investigated were: heating fuel, renters paying extra for electricity, renters paying extra for gas, bathtub or shower facilities, flush toilet facilities, telephone availability, year structure built, seasonal vacancy status, renters paying extra for water, renters paying extra for other fuels and value of home.

The US sample for the re-interview was a three-stage design. The first stage involved the selection of the primary sample units where a primary sampling unit was either a county, a group of counties or a standard consmopolitan area. The second stage of the selection involved a systematic selection of a subset of the census sample of households within each selected primary sampling unit such that each cluster was expected to include two 5-per cent addresses and six 15-per cent addresses. At the final selection each of the 5 per cent addresses were selected and two out of the six 15-per cent addresses selected. These addresses relate to those in the US census long-form sample who had been selected to complete 5 per cent and 15 per cent long form questionnaires respectively. Since the selection was based on a sample, it was obvious that any measures of consistency obtained as the result of the re-interview were subject to sampling errors.

Table 1 DISTRIBUTION OF CENSUS AGE DISCREPANCIES (reckoned in 5-year groups) BY P.E.S. AGE AND SEX*

Percentages

P.E.S. AGE	ALL PERSONS	CENSUS AGE: IN A YOUNGER GROUP BY: 10 or more years	5-10 years	1 day to 5 years	TOTAL	IDENTICAL AGE GROUP as in P.E.S.	IN AN OLDER GROUP BY: TOTAL	1 day to 5 years	5-10 years	10 or more years	NET DISCREPANCY: Persons in Census Older (+) Younger (-)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						I. MALES					
0-4	100.0	—	—	—	—	87.2	12.8	11.2	1.2	0.4	12.8
5-9	100.0	—	—	12.3	12.3	73.3	14.4	12.1	1.3	1.0	2.1
10-14	100.0	—	2.7	16.1	18.8	61.3	19.9	14.7	2.9	2.3	1.1
15-19	100.0	—	1.7	14.4	16.1	65.2	18.7	12.7	3.6	2.4	2.6
20-24	100.0	0.4	1.7	14.8	16.9	51.5	31.6	19.3	5.5	6.8	14.7
25-29	100.0	2.8	1.3	15.3	19.4	47.9	32.6	16.1	8.8	7.7	13.2
30-34	100.0	0.5	4.1	17.3	21.9	42.1	35.9	18.2	7.8	9.9	14.0
35-39	100.0	1.5	8.6	27.4	37.5	33.8	28.7	13.1	6.5	9.1	-8.8
40-44	100.0	4.7	10.6	16.1	31.4	32.7	35.9	18.9	6.2	10.8	4.5
45-49	100.0	7.5	5.3	17.5	30.3	35.9	33.8	14.4	10.0	9.4	3.5
50-54	100.0	12.2	8.2	15.3	35.7	33.8	30.4	8.5	10.8	11.1	-5.3
55-59	100.0	7.3	12.9	19.3	39.5	33.5	27.0	9.4	6.4	11.2	-12.5
60-64	100.0	15.1	13.0	14.0	42.1	30.8	27.1	14.1	4.9	8.1	-15.0
65 and over ..	100.0	17.5	15.0	21.1	53.6	24.4	22.0	7.8	5.3	8.9	-31.6
All ages (sample)..	100.0	2.6	3.6	13.2	19.4	57.7	22.9	13.5	4.5	4.9	3.5
All ages (adjusted)	100.0	2.6	3.6	13.5	19.7	58.3	22.0	13.7	4.3	4.0	2.3
						II. FEMALES					
0-4	100.0	—	—	—	—	85.2	14.8	12.2	1.9	0.7	14.8
5-9	100.0	—	—	13.6	13.6	73.3	13.1	11.8	1.2	0.1	-0.5
10-14	100.0	—	2.1	18.4	20.5	69.1	10.4	9.1	0.6	0.7	-10.1
15-19	100.0	0.2	2.3	10.2	12.7	61.6	25.7	19.1	5.1	1.5	13.0
20-24	100.0	0.1	0.3	9.7	10.1	55.9	34.0	22.9	8.4	2.7	23.9
25-29	100.0	1.1	3.7	22.8	27.6	42.1	30.3	18.6	6.3	5.4	2.7
30-34	100.0	3.0	10.1	22.5	35.6	36.5	27.9	14.7	10.4	2.8	-5.2
35-39	100.0	5.3	12.2	22.0	39.5	34.1	26.4	14.4	6.7	5.3	-13.1
40-44	100.0	5.3	6.9	18.7	30.9	39.9	29.2	17.3	7.4	4.5	-1.6
45-49	100.0	16.2	9.6	22.0	47.8	22.7	29.5	18.2	5.8	5.5	-18.3
50-54	100.0	20.2	12.1	15.2	47.5	29.6	22.9	9.4	4.5	9.0	-24.6
55-59	100.0	26.0	16.7	11.7	54.4	14.8	30.8	11.7	9.9	9.2	-23.5
60-64	100.0	23.3	17.0	13.4	53.7	27.8	18.5	10.3	4.1	4.1	-35.1
65 and over ..	100.0	31.2	7.9	13.9	53.0	25.2	21.8	4.1	9.5	8.2	-31.2
All ages (sample)..	100.0	4.3	4.3	13.8	22.4	55.9	21.7	14.1	4.8	2.8	-0.7
All ages (adjusted)	100.0	4.1	4.2	13.8	22.1	57.6	20.3	13.6	4.3	2.4	-1.8

* Reproduced from Table 29.2.1 'b' of 1960 Population Census of Ghana Report, Volume V. Census Office, Accra, 1964.

Table 2 – REPORTS ON REGION OF BIRTH IN CENSUS AND P.E.S. BY SEX – ADULTS (only)*

Absolute numbers and Percentages

REGION IN CENSUS	SEX	ALL REGIONS	WESTERN	ACCRA C.D.	EASTERN	VOLTA	ASHANTI	BRONG-AHAFO	NORTHERN	BORN ABROAD	NOT STATED
		REGION IN P.E.S.									
		I. ABSOLUTE NUMBERS									
Total born in Ghana	T	3,255,382	666,788	186,495	551,705	361,612	441,432	236,359	648,050	138,959	23,982
	M	1,574,048	318,412	87,316	277,620	164,624	202,081	123,158	309,430	77,859	13,548
	F	1,681,334	[illegible],376	99,179	274,085	196,988	239,351	113,201	338,620	61,100	10,434
WESTERN	M	334,346	[illegible],931	8,700	3,127	1,081	4,136	3,579	341	7,110	341
	F	355,743	339,11[illegible]	870	1,909	612	3,912	—	204	3,972	5,150
ACCRA C.D. ..	M	123,051	9[illegible]3	64,381	42,758	440	1,482	—	—	13,037	—
	F	110,395	—	80,700	21,276	5,627	—	—	631	2,161	—
EASTERN	M	248,813	4,533	11,346	219,509	4,592	2,677	—	—	1,520	4,636
	F	267,024	2,495	14,915	239,048	1,724	1,020	—	—	7,063	759
VOLTA	M	168,026	—	1,019	1,309	158,489	759	131	759	5,560	—
	F	197,245	147	1,382	2,315	186,705	530	—	402	5,509	255
ASHANTI	M	251,648	6,940	1,870	10,917	—	186,447	3,426	7,708	25,791	8,549
	F	260,189	4,241	1,283	9,242	2,320	223,964	6,356	2,638	10,145	—
BRONG-AHAFO ..	M	138,382	—	—	—	—	6,395	115,967	12,603	3,417	—
	F	130,990	2,314	—	295	—	9,795	106,686	9,264	295	2,341
NORTHERN	M	309,782	55	—	—	22	185	55	288,019	21,424	22
	F	359,748	65	29	—	—	130	159	325,481	31,955	1,929
BORN ABROAD ..	T	439,878	5,012	6,873	10,159	7,955	3,772	—	[illegible]3,108	370,882	7,117
	M	301,857	4,371	4,363	6,374	4,606	2,686	—	16,263	256,077	7,117
	F	138,021	641	2,510	3,785	3,349	1,086	—	11,845	114,805	—
TOTAL BY REGION P.E.S. REPORTS ..	T	3,695,260	671,800	193,368	561,864	369,567	445,204	236,359	676,158	509,841	31,099
	M	1,875,905	322,783	91,679	283,994	169,230	204,767	123,158	325,693	333,936	20,665
	F	1,819,355	349,017	101,689	277,870	200,337	240,437	113,201	350,465	175,905	10,434
CENSUS REPORTS ..	T	3,695,260	690,089	233,446	515,837	365,271	511,837	269,372	669,530	439,878	—
	M	1,875,905	334,346	123,051	248,813	168,026	251,648	138,382	309,782	301,857	—
	F	1,819,355	355,743	110,395	267,024	197,245	260,189	130,990	3[illegible],748	13[illegible],021	—
DISCREPANCY: (+) more, (–) less in Census ..	T	—	18,289	40,078	-46,027	-4,296	66,633	33,013	-[illegible]	-[illegible],963	-31,099
	M	—	11,563	31,372	-35,181	-1,[illegible]04	46,881	15,224	-15,911	-[illegible],079	-20,665
	F	—	6,726	8,706	-10,846	-3,092	19,752	17,789	9,2[illegible]3	-37,884	-10,434
		II. PERCENTAGES									
Total born in Ghana	T	100.0	20.5	5.7	16.9	11.1	13.6	7.3	19.9	4.3	0.7
	M	100.0	20.2	5.6	17.6	10.5	12.8	7.8	19.7	4.9	0.9
	F	100.0	20.7	5.9	16.3	11.7	14.2	6.8	20.1	3.7	0.6
WESTERN	M	100.0	91.5	2.6	1.0	0.3	1.2	1.1	0.1	2.1	0.1
	F	100.0	95.3	0.3	0.5	0.2	1.1	—	0.1	1.1	1.4
ACCRA C.D. ..	M	100.0	0.7	52.3	34.8	0.4	1.2	—	—	10.6	—
	F	100.0	—	73.1	19.3	5.1	—	—	0.6	1.9	—
EASTERN	M	100.0	1.8	4.5	88.2	1.9	1.1	—	—	0.6	1.9
	F	100.0	0.9	5.6	89.5	0.5	0.4	—	0.2	2.6	0.3
VOLTA	M	100.0	—	0.6	0.7	94.3	0.5	0.1	0.5	3.3	—
	F	100.0	—	0.7	1.2	94.7	0.3	—	0.2	2.8	0.1
ASHANTI	M	100.0	2.8	0.7	4.3	—	74.1	1.4	3.1	10.2	3.4
	F	100.0	1.6	0.5	3.6	0.9	86.1	2.4	1.0	3.9	—
BRONG-AHAFO ..	M	100.0	—	—	—	—	4.6	83.8	9.1	2.5	—
	F	100.0	1.8	—	0.2	—	7.5	81.4	7.1	0.2	1.8
NORTHERN	M	100.0	—	—	—	—	0.1	—	93.0	6.9	—
	F	100.0	—	—	—	—	—	0.1	90.5	8.9	0.5
BORN ABROAD ..	T	100.0	1.1	1.6	2.3	1.8	0.9	—	6.4	84.3	1.6
	M	100.0	1.5	1.4	2.1	1.5	0.9	—	5.4	84.8	2.4
	F	100.0	0.5	1.8	2.7	2.4	0.8	—	8.6	83.2	—
TOTAL BY REGION P.E.S. REPORTS ..	T	100.0	18.2	5.2	15.2	10.0	12.0	6.4	18.3	13.8	0.9
	M	100.0	17.2	4.9	15.1	9.0	10.9	6.6	17.4	17.8	1.1
	F	100.0	19.2	5.6	15.3	11.0	13.2	6.2	19.3	9.7	0.5
CENSUS REPORTS ..	T	100.0	18.7	6.3	14.0	9.9	13.8	7.3	18.1	11.9	—
	M	100.0	17.8	6.6	13.3	8.9	13.4	7.4	16.5	16.1	—
	F	100.0	19.5	6.1	14.7	10.8	14.3	7.2	19.8	7.6	—
DISCREPANCY (in percentage points): (+) more, (–) less in Census	T	—	0.5	1.1	-1.2	-0.1	1.8	0.9	-0.2	-1.9	-0.9
	M	—	0.6	1.7	-1.8	-0.1	2.5	0.8	-0.9	-1.7	-1.1
	F	—	0.3	0.5	-0.6	-0.2	1.1	1.0	0.5	-2.1	-0.5

* Reproduced from Table 29.2.2 of 1960 Population Census of Ghana Report, Volume V. Census Office, Accra, 1964.

16. In the Ghana example of 1960 a sample of 5 per cent of the enumeration areas used for the census was selected for the coverage check and matched and discrepancies based on the degree of inconsistency between the census totals and the PES totals for those EAs calculated. Then the sample was stratified on the basis of the magnitude of the discrepancy. Then a sub-sample of 59 enumeration areas or approximately one-half of 1 per cent of the total EA's used for the 1960 census was selected for intensive matching of results and also for field reconciliation.

17. These reconciliation interviews help to reduce the discrepancies between the census and the PES data in most cases. It should be noted as stated earlier that the PES itself is subject to error and as such discrepancies do not necessarily indicate the level of error in the census data. However, in a reconciliation check where both replies are available to the reconciliation interviewer, it is possible with probing questions to find out which of the two answers is more likely to be correct.

Matching of Census Data with Independent Survey Results

18. The possibility of not undertaking a special re-interview survey but to match the results of the census with an independent survey conducted about the same time enables the cost of an evaluation programme to be substantially reduced. However, in many developing countries, especially in Africa, such independent surveys are infrequent and in any case steps are usually taken to ensure that no surveys are carried out at about the time of the census so that the respondents would not be confused about the census and the survey. Thus the matching of census data with independent survey results is not a common phenomenon in the African region. It may however be possible to match census data with independent results of a survey carried out in a rather restricted fashion, that is, a survey which is limited to either a few enumeration areas or a few villages.

19. In its evaluation and research programme, the US Bureau of the Census has for a number of past censuses matched its census data with information from the Current Population Survey (CPS) (US Bureau of the Census, 1975). The 1970 matching was based on members of households included in the 20-per cent sample of the 1970 Census and the March 1970 Current Population Survey. It may be recalled that the CPS is conducted every month by the US Bureau of the Census and this involves a total of 50,000 households.

20. As a result of the matching, estimates of gross and net error and the index of inconsistency were calculated in respect of the following characteristics:

Age
Sex
Race
Relationship to household head
Marital status
Years of school completed
Veteran status

Employment status
Work experience in 1969
Occupation
Industry
Class of worker
Income in 1969
Poverty status in 1969

The results of the matching show that for index of inconsistency (see Annex 1 for definition) exceeded 25 for a number of variables. The following is a selection:

(a)	Relationship to head	- male, non-relative (29) - female, non-relative (27)
(b)	Marital status	- male, separated (43) - female, separated (29)
(c)	Years of school	- all categories except college 5 years or more (the L-fold index was 38. Also for persons aged 25 or more, 65.2 per cent were in the same category as the CPS classification).
(d)	Veteran status	- Veteran, other service (32)
(e)	Employment status	- both sexes, - L-fold index (18), employed in agriculture (30), unemployed (61) - males - L-fold index (19), employed in a agriculture (26), unemployed (58) - females - L-fold index (20), employed in agriculture (63), unemployed (63)
(f)	Major occupation	- L-fold index (26), managers and administrators, except farm (39), sales workers (30), craftsmen and kindred workers (30), Transport equipment operatives (26), labourers, except farm (49) farm laborers and farm foremen (27).

The results of the US Bureau of the Census have been highligted in the absence of recent data on content error evaluation based on the matching of two sets of data in African countries. It may however be recalled that the Report of the 1960 Population Census of Ghana, Volume V also shows similar types of discrepancy, with the disparities more pronounced for age and the economic characteristics data. Some of the discrepancies in the latter may reflect real and acceptable results since there are frequent changes in economic activity and occupation over relatively short periods. Thus for some of these characteristics, a large index of inconsistency may not be a reflection of poor data. Tables 1 and 2 show the results of the 1960 Ghana Census - PES match for age and birthplace. It should be noted that for age the discrepancies are greater if single years of age are considered. The place of birth data indicate a lower level of inconsistency except in one region, Accra C.D. This is partly explained by the administrative confusion over one district, Ada.

Tape Recording

In recent times attempts have been made to measure error in censuses and surveys by tape recording some of the interviews. It is claimed that by using these tape recordings in conjunction with the survey questionnaires it is not only possible to identify some of the sources of the errors but an indication of the magnitude and direction of these response errors can be obtained. Gibril (1979), in his study evaluating census response errors, describes such an exercise in which the transcripts of tapes containing recorded interviews for the 1973 Census of Gambia were used to

attempt to obtain some measures of the response errors of the census. As far as it is possible to determine from this study, it is possible to measure the deviations of the information as given during the interviews and information as recorded in the questionnaires for the sample investigated. But, as the study shows, there are distortions both in the recorded information on the tapes and the recorded information on the questionnaires. However, some of the distortions appear to have been magnified by the interviewers in recording the information given to them. The following table which is based on 363 women covered by the study out of whom 209 were reported to be aged 15 years and over shows the discrepancies between the tape recordings and the questionnaires as compared with the record checks provided by the Medical Research Council referred to earlier in Paragraph 8.

Tale 3

Mean Parities Reported from Three Sources

Age	Tape Recordings	Questionnaires	MRC
15-19	0.447	0.500	0.814
20-24	2.357	2.571	2.027
25-29	2.828	3.310	3.327
30-34	4.370	4.889	5.227
35-39	4.500	4.636	6.063
40-44	4.438	6.125	6.185
45-49	5.727	7.000	7.000
50+	5.541	6.027	7.029

This table on Mean Parities Reported from three sources shows not only significant differences between the tape recordings and the questionnaires but show rather big differences between the information obtained from the census either through the tape recording or through the questionnaires and those obtained by the Medical Research Council. If the MRC information is used as standard, it is possible to obtain measures of errors using either the questionnaire or the tapes.

Reponse Error Measures

It is important to note that the total effect of response errors derived from both reporting as well as processing, on the final results is to introduce bias, distort relationships among variables and introduce variability in the classification process over repeated trials. Thus obtaining some measures of this types of error helps not only to guide the user as to the reliability he should attach to the data but also helps the producer to make efforts to improve the planning and organization of similar operations in future.

The four main measures of response errors usually applied in connexion with census evaluation are: the index of inconsistency, the gross difference rate, the net difference rate and the per cent identically distributed. The first of these measures is defined simply as:

$$I = \frac{\text{Simple response variance}}{\text{Total variance}}$$

which measures that part of the total variability which is due to response. The more theoretical treatment of this index is given in the paper by Hansen et al (1961-1964). The simplified form for its computation is given in Annex 1. The L-fold index of inconsistency is used for distributions with more than two categories and this is defined as the weighted average of the individual indexes computed for each category of the distribution.

The gross difference rate measures the sum of the total number of persons differently classified in the two surveys as a proportion of the total number of persons in the re-interview/independent survey matching study. This concept is also illustrated in Annex 1. A high value of this proportion indicates that a large number of people were differently classified in the two surveys. The value of the index is 100 if all persons are differently classified in the two surveys.

Net difference rate: the net difference rate for a particular category of interest is the difference between the census and reinterview or independent survey proportion of persons in that category. The simplified diagram below shows the classification into two categories of information in respect of the same sample of persons in two surveys: the census and re-interview/independent survey

Re-interview	Census I (in category	Census II (not in category)
I	a	b
II	c	d

with a + b + c + d = n, the total sample size.

The net difference rate is then defined as

$\frac{c - b}{n} \times 100$, while the gross difference rate is $\frac{b + c}{n} \times 100$.

Thus a positive value of the net difference rate indicates that the proportion of persons in the census in that category is greater than the proportion of persons in the reinterview, while a negative value indicates that a census proportion is less than the reinterview proportion. On the assumption that the reinterview or PES is more accurate than the census, then the difference between the census and the reinterview which is not accounted for by sampling variability indicates a bias in the census results and the bigger the net difference rate the bigger the bias.

<u>The last index is the per cent identically distributed</u>. In the simplified diagram given above this response is the proportion of persons with identical categorization in both the census and reinterview, i.e., $\frac{a + b}{n} \times 100$.

The more detailed specifications of these indexes is given in Annex 1. In studies done on the 1960 census of Ghana it was shown that there was very high correlation between 100-I and the per cent identically distributed and this raised the question whether this index could not for all practical purposes be substituted for the index of inconsistency. It was, however, argued that while the properties of the index of inconsistency have been investigated and there are also theoretical basis for its derivation, the per cent identically distributed does not lend itself to such a sophisticated treatment.

Conslusions

In preceding paragraphs, an attempt has been made to summarise some of the techniques commonly used for the statistical evaluation of census and survey data. Other approaches of data evaluation through the use of analytical techniques in the demographic field are dealt with in a separate paper. In view of the rather complex and costly nature of the techniques usually adopted for content error evaluation, it is necessary to adopt a careful strategy to be followed in this field of checking the quality of data obtained from censuses and surveys.

One of the elements to be considered in the formulation of this strategy is priority setting. This should involve not only the selection of items for evaluation but also the appropriate mechanism for achieving the objective. For example, for the evaluation of age-sex data where there are acceptable techniques in the field of demographic analysis, it would seem appropriate to leave this to this mechanism which does not involve costly field operations and matching procedures. For the rest, it is necessary to discriminate on the basis of past experience to ensure that only those items which show a significant level of error in censuses are retained for the more complex evaluation programme. In the Ghana example previously cited if past censuses have indicated a high level of consistency on place of birth data, it would seem to constitute a waste of resources to continue to evaluate the accuracy of this data. On the other hand the item "relation to head of household" may still require evaluation checks in view of the level of error consistently found in the data.

Another consideration is that evaluation of data generally requires more sophisticated expertise which not all statistical offices in the region possess. Thus, before embarking on a programme of evaluation, it is necessary to take an inventory of the human resources available to implement it. In the absence of these resources, it would be prudent to abandon the programme unless external technical assistance can be provided. The risk in undertaking the programme without the proper staff is usually the provision of estimates of reliability of the data which are grossly misleading.

The third element to consider is an adequate budget for these checks. It is not unusual for the census budgets to be exhausted before evaluation checks are completed. To avoid this, it is necessary to make adequate and separate provision for coverage and content error evaluation in the census budget. To economise, some countries have combined checks for coverage and content errors in the same field operations. Since the operations have different objectives and require usually different design specifications, such a combination normally yields unsatisfactory results for both operations. Thus it is essential that the two operations be kept separate.

It should also be noted that for re-interviews as part of evaluation checks to be effective, the reinterviewers should be independent of the original census interviewers. In countries where a completely independent evaluation field staff is impossible, the census supervisors could be used as reinterviewers. It should however be borne in mind that the independence of the two operations gives an assurance that consistency between the two sets of responses is a measure of the quality of the data obtained.

Under present African conditions, the reinterview sample size will have to be relatively small, thus leading to large standard errors of the estimates obtained. This is preferable to larger samples which lead to unsatisfactory and unacceptable results.

It should be noted also that a reconciliation check based on a sub-sample of the reinterview sample may have to be carried out to attempt to reconcile discrepancies between the census and the reinterview.

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Computation of Response Error Measures and their 95 per cent confidence intervals

This section presents with examples, the computational forms of the response error measures used in this report

DISPLAY OF CROSS-TABULATED DATA

General procedure

Display of cross-tabulated data for characteristic with L categories (L 2). The general term X_{ij} represents the number of unweighted sample elements in the reinterview and j^{th} category in the census.

Reinterview (i-1, ...,L)	Census (j - 1, ...,L): Total	Not reported in census[2]	Reported in census: Total reported	Category 1	Category 2	...	Category j	...	Category L
Total	$n'_{..}$[1]								
Not reported in reinterview[2]									
Reported, total			$n_{..}$[3]	$X_{.1}$	$X_{.2}$	....	$X_{.j}$	...	$X_{.L}$
Category 1			$X_{1.}$	X_{11}	X_{12}	...	X_{1j}	...	X_{1L}
Category 2			$X_{2.}$	X_{21}	X_{22}	...	X_{2j}	...	X_{2L}
.			.	.	.	.	.	.	.
Category i			$X_{i.}$	X_{i1}	X_{i2}	...	X_{ij}	...	X_{iL}
.			.	.	.	.	.	.	.
Category L			$X_{L.}$	X_{L1}	X_{L2}	...	X_{Lj}	...	X_{LL}

Example of procedure

Year structure built
(artificial data)

Reinterview	Census: Total	Not reported in census	Reported in census: Total reported	1969 or later	1965 to 1968	1960 to 1964	1950 to 1959	1940 to 1949	1939 or earlier
Total	1,325	64	1,261	46	122	169	321	175	428
Not reported in reinterview	51	8	43	3	2	10	8	3	17
Reported, total	1,274	56	1,218	43	120	159	313	172	411
1969 or later	43	5	38	27	6	1	3	0	1
1965 to 1968	124	2	122	11	85	14	8	0	4
1960 to 1964	173	13	160	2	20	111	18	5	4
1950 to 1959	306	12	294	0	4	27	237	12	14
1940 to 1949	151	4	147	0	1	0	27	95	24
1939 or earlier	477	20	457	3	4	6	20	60	364

[1] $n'_{..}$ is the total number of sample cases. In the actual data tables, row 1 and column 1 contain the appropriate marginal totals.

[2] In the actual data tables, row 2 and column 2 contain the numbers of cases for which there was no report for that item in either the census or reinterview.

[3] $n_{..}$ is the total number of sample cases for which there was a report in both the census and reinterview; that is, the total sample cases minus the "not reported" cases.

Reproduced from: Accuracy of Data for Selected Housing Characteristics as Measured by Reinterviews, 1970 Census of Population and Housing, April 1975.

EVLUATION STATISTIQUE DES ERREURS DE CONTENU

Dans le présent document, on examine brièvement les principaux objectifs de l'évaluation des erreurs de contenu, à savoir : donner une idée de la fiabilité des données et fournir des orientations pour l'amélioration du plan et de l'organisation des recensements et enquêtes futurs. Y sont également examinées les trois méthodes d'évaluation des erreurs de contenu. Il s'agit de la vérification des documents, des entrevues répétées avec ou sans conciliation et du collationnement des données des recensements avec les résultats d'enquêtes indépendantes. Ces trois méthodes impliquent l'application de différentes techniques qui sont exposées dans l'étude. L'emploi de magnétophones pour vérifier la fiabilité des réponses est également mentionné.

Quatre formes principales d'évaluation des erreurs de déclaration généralement appliquées à l'évaluation de la qualité des données des recensements sont examinées. Ce sont l'indice de non-concordance, le taux brut de différence, le taux net de différence et les pourcentages ventilés de façon identique. La nécessité d'établir un ordre de priorité dans le choix des éléments à évaluer et le mécanisme approprié à employer pour atteindre l'objectif du programme d'évaluation sont également examinés. La nécessité de disposer d'un budget suffisant et de connaissances techniques plus perfectionnées pour l'évaluation est en outre soulignée.

ANALYTICAL TECHNIQUES FOR CONTENT ERROR EVALUATION

by

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INTRODUCTION

The collection and analysis of data about various aspects of human behaviour - economic, social, demographic and psychological - is one of the primary concerns of statisticians. For Seltzer, among these broad areas, demographic statistics present the least collection problem because they are more thoroughly understood; the basic concepts are defined in a way that is both logically tenable and adequate to reality; they are the simplest and easiest to obtain from a population (Seltzer, 1973). However, due to several definitional, conceptual and manifold instabilities that affect the instruments and circumstances of demographic data collection, Seltzer argues that demographic statistics are subject to different types of errors, biasses and deficiences. Accordingly, although the demand for statistical information is growing increasingly and rapidly and survey organizations are hard pressed to supply results with the required speed, it is essential to detect these errors and indicate their approximate magnitude through evaluation and analysis so that users may be aware of the limits of accuracy of the data they are using. Since the main thrust of demographic data evaluation and analysis is the assessment of the quality of the collected data as well as the establishment of the degree of confidence which users of the data should place on them, only a few topics will be treated in this study.

Among the selected topics are (a) age; (b) number of children ever born; (c) children dead among those ever born; (d) place of birth. Although there is no main criterion for selecting these particular topics, the inclusion of topics on fertility, mortality and migration is understandable. The emphasis on age is predicated on two principles. First, virtually every aspect of human behaviour, from subjective attitudes and physiological capabilities to subjective characteristics such as income, labour force participation, occupation or group membership is expected to vary with age. Secondly, many of the special needs and problems of a particular society, both now and in the future, is determined in large measure by the age structure of its population. Besides these two main considerations, age data are vital for a correct evaluation of current patterns of fertility and mortality and for making any sort of reliable population estimates. Thus a major prerequisite for an adequate determination of the present needs of a given society as well as for sound planning regarding probable future needs is a thorough familiarity with the age composition of its population.

Besides the delimitation of the topics for this study, it is pertinent as well to note two related issues. First, four components constitute the whole process of demographic data evaluation and analysis - the determination of the level of accuracy of the data; indicating their limitations; isolating types of errors; and identifying their probable causes. The analytical techniques to be discussed below for evaluating errors in the selected topics will as much as possible focus on these components. Secondly, it should be noted that even when great care has been taken to set up important controls while collecting demographic data, it is still necessary to get an assurance that the controls

were effective and the results with the desired accuracy have been obtained. For practical purposes the desired accuracy can be specified as the margin of "permissible errors" in the sense that any decision to be taken on the basis of sample estimates would remain the same within the limits of the permissible errors. Thus there is general concensus among experts that survey reports should contain some idea of the reliability and/or validity of the results.

II. SOME RELEVANT CONCEPTS OF ERRORS AND THEIR PROBLEMS

Reliability is the accuracy or precision of a measuring instrument. It can be defined in terms of the stability, dependability, accuracy, predictability and the relative absence of errors of measurement in a measuring instrument (Kerlinger, 1964: 429-462). To be interpretable, a test must be reliable. Unless one can depend upon the results of the measurement of one's variables, one cannot with any confidence, determine the relations between the variables. High reliability is of course no guarantee of good scientific results, but there can be no good scientific results without reliability. Reliability is thus a necessary but not a sufficient condition of the value of research results and their interpretation. On the other hand, validity demands that the measurement be relatively free of error. The usual characterization of a valid measurement is that it is one which "measures what it purports to measure". The commonest definition of validity is epitomized by the question: Are we measuring what we think we are measuring? Four types of validity are usually discerned - content, predictive, concurrent and construct.1/

An indepth analysis of the foregoing conceptualizations regarding reliability and/or validity is not the focuss of this paper. Rather the goal is to review some of the analytical techniques for content error that exist in data from censuses of population/housing and surveys. One source of error is inherent to the measuring instrument (Kaplan, 1964: 199-214). For every instrument there is a limit to the discriminations it can make. Differences that fall below this limit are not recognized, and objects that differ thus slightly are measured as equivalent. The discriminating power of an instrument or procedure of measurement is known as its sensitivity. One source of error, then, is insufficient sensitivity.

A second type of error consists in the fact that when a measurement is repeated it does not, in general, yield identical results. There is inevitably a certain amount of variation among the outcomes of repeated measurements; these are said to be subject to "random fluctuation". Each measurement may thus be conceived as having two components, the first corresponding to the magnitude being measured and the second consisting of a positive or negative deviation produced by other and uncontrolled factors. The smaller these deviations, the more reliable the measurement is said to be; reliability, in other words, is in turn a measure of the extent to which a measurement remains constant as it is repeated under conditions taken to be constant. Among these conditions, the observer making the measurement is of particular importance, especially in behavioural science. Accordingly, reliability is often interpreted as a kind of intersubjectivity: the agreement of different observers on the measures to be assigned in particular cases. But changes in the circumstance of measurement other than the identity of the person making the measurement are also involved in reliability.

1/ Technical recommendations for Psychological Tests and Diagnostic Tests and Diagnostic Techniques, Psychological Bulletin, LI (1954), supplement, pp. 201-238. See also Ghonbach, L. and Meehl, P., "Construct validity of psychological tests", Phychological Bulletin, L II (1955), pp. 281-302.

The most comprehensive classification of the different types of errors and biasses in collected data was made by Deming (1944). In his classic article, Deming lists thirteen factors which affect the quality of research findings. Among these factors, variability in response, method of enumeration, interviewer's bias, bias of the auspices, questionnaire design, bias from nonresponse, and unrepresentative sample, affect the operational aspects of the survey. Very little is known about the factors causing variability in the results of a survey, as variability of response is to be expected even under the best enumerating conditions. Questions which are poorly worded, definitions which are inadequately stated and lack of attention in the training of enumerators not only intensify this variability, but are the cause of unreliability in the sense of leading to bias. However, the effect of this variability is encouragingly small. According to Palmer (1943: 143): "Many inconsistencies in reporting are inevitably compensating in character when the data are combined into frequency distributions". Palmer's argument is that the effect of variability in response on the results of the survey should not be too distorting providing that definitions are adequate, questions worded suitably, and the interviewers trained thoroughly. In this respect, conditions are almost the same in developed as in developing countries, except that in the latter it may be relatively more difficult to obtain the enumerators who can be thoroughly trained, or to arrive at definitions and questions which are really unambiguous to the respondents, a large proportion of whom are illiterate.

With respect to the various kinds of canvass, it is perhaps safe to lay down as a general rule that only the direct interview is to be used for all types of surveys. The reason is too obvious to need any elaboration. Bias and variation among interviewers arise from the dishonesty, laziness and disinterestedness of interviewers. They may decide that it is too troublesome to call back on households or they may simply think it is not worthwhile to go all that way to a remote village to collect information which they think is not of great importance. It is of no avail to pay by completed interviews, for this will simply encourage them to fake information; and this is even more dangerous than having no information at all. The only way out of this difficulty is to train them thoroughly, give them a sense of the importance of their work, and keep a constant check on them. In demographic surveys they should be trained to conduct the in terview in an easy, conversational manner and to avoid pompous formality which may arouse fear and hence lead to misinformation. With respect to the problem of bias of the auspices, Jaff has given a very exhaustive and reasoned argument, against the government's sponsoring or taking an active part in any survey (Jaffe, 1943). It may be asked, if not the government, who else? The suggestion is that the government should set up some institute to carry out certain survey projects (Seng, 1949). In the case of imperfections in the design of the questionnaire, the suggestions are that questionnaires should be simple, and should contain only questions that do not overtax the memory of the respondents or clash with the superstitious fears of the people. A pilot survey must, among other things, test the adequacy of any questionnaire, and interviewers should be asked to detect and comment on any resistance against any question and to find out the reason for this.

The variability due to non-response depends to a very large extent on the definitions of the different terms used and on the auspices under which the survey is taken. Taken by itself, it is generally found that in developing countries the more backward the people,

the more willing they are to supply information 2/. Of course, it is not to be presumed that the information is necessarily accurate as the respondents are largely uneducated and ignorant and their inclination to superstition may cause them, consciously or otherwise, to conceal some information. One explanation for this may be the hope that the authorities will be brought to realize their miseries and therefore will do something to improve their lot. Interviewers not only should be well trained but they should be informed of the local superstitions so that they can counter these and extract the right information from the right people.

This treatment of operational problems in surveys is not exhaustive. Each survey has its own operational problems, every country its own peculiarities, its own traditions, and it unlikely that any discussion will cover all cases. The point is that operational biases and errors are formidable factors to reckon with in surveys, and that developing countries have their own operational problems which are much worse than those in more advanced countries.

III. CLASSIFICATION OF ERRORS

Drawing from the foregoing detailed classification of errors and associated problems a rather broad categorization of these errors with illustrations from demographic data has been discussed in an earlier study by the Population Programme Centre of the ECA secretariat (ECA, 1973). The said study distinguished between:

(a) coverage and content errors;

(b) errors having their origin in sampling;

- (i) sampling errors;
- (ii) sampling biases.

(c) errors common to both censuses and samples surveys

- (i) errors due to inadequate preparation;
- (ii) errors of non-response or incomplete sample;
- (iii) response or ascertainment or observational errors;
- (iv) processing errors;
- (v) errors in constructing estimates;
- (vi) errors in interpretation;
- (vii) errors in publication.

No attempt will be made to review the highlights of the study under reference since the edited version has been published and widely distributed (ECA, 1975). However, the distinction between coverage and content errors is pertinent to the present study. For a given survey, if in a particular area, some households or persons, for example, are not covered at all or enumerated more than once, this would be coverage error. But, if a particular unit is covered and there is an error in recording one of its characteristics

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2/ This was found to be true in Malaya, according to Mr. Del Tufo, Superintendent of the Census, (1974), see Population Studies (Cambridge University Press, September 1949), 3, p. 189.

(eg. age of a person), that would be content error. Analysis in the succeeding sections will focuss on analytical techniques for content error evaluation of demographic statistics on-age; number of children ever born and those surviving by age of women aged 15-49; number of current and restrospective deaths by age of women 15-49; and, place of birth.

IV. ERRORS IN AGE STATISTICS

An accurate enumeration of the population classified by age involves many difficulties. Inadequacies in age statistics arise from two basic sources; failure to report ages (especially for very young children who are often not thought of as full members of the society); deliberate misstatements of ages. The latter may arise from ignorance of the correct age; a tendency to understate at some ages while exaggerating at others - particularly at the more advanced ages; either a concious or subconcious preference for certain socially significant ages and a corresponding avoidance of other ages; a general tendency to over-select ages ending in certain digits; and, deliberate falsification of age reports for a variety of social, economic, political or purely individual motives. In the reporting of age from census/survey returns, there arise five major forms of content errors and biasses (Myers, 1954). These include the underreporting of the number of the children aged under one; a tendency to give exact age of some legal significance (eg. voting at elections, marriage, etc.); distinct overstatement of age among those at very advanced ages; the reporting of some individuals as being of an unknown age; age heaping.

(i) Understatement of population under 1

The most obvious method for analysing the tendency to underreport the population under one is to consider the per cent single age distribution of children under 5 and compare same with the proportions from a corresponding life table. For a life table, the proportions under 1, 1-2, 2-3, 3-4 and 4-5 should not differ significantly per succeeding time interval. Suppose there are national life tables for two years (eg. 1960 and 1970), the proportions 0-1, 1-2, 2-3, 3-4 and 4-5 should remain constant at both years because of the fixity of mortality and fertility in a stationary population. But for each of the periods (eg. 1960), the expected pattern for a stationary population is that the proportion under 1 should exceed that of 1-2; the proportion 1-2 should exceed that of 2-3, etc. This expected pattern for the stationary model can be used to evaluate the extent of under-reporting the population under 1 in an actual situation. The percentages (0-1, 1-2, 2-3, 3-4 and 4-5) should decrease with age because of mortality if there was an equal number of births in each of the last five years. If the proportion under 1 is slightly less than that of 1-2, then underreporting of the population under 1 would be indicated.

For purposes of illustration, consider the case of Ghana with data from the 1960 and 1970 censuses (Table 1). Although there is no national life table of Ghana for both years to use as a yardstick for evaluating the extent of underreporting the population under 1, it is clear from the data (Table 1) that there was considerable overreporting (as against underenumeration) of the population under 1 in 1960 relative to 1970. The lack of a corresponding stationary population is a handicap to the ability of the analyst to ascertain the nature and extent of reporting the population under 1 in Ghana and for both years.

The alternative procedure of comparing the enumerated population in the census year with that estimated by projecting births of previous years 3/ is equally problematic since the exact number of annual births is not definitely known due to underreporting element and incompleteness of registration.

(ii) Socially significant age

The test for detecting errors resulting from the tendency to give an exact age of some legal significance is quite simple and straightforward. Suppose the age at which adolescents can vote (or marry) for example is X, one way of checking reported errors in X is to compute the ratio of the population at age X to that at age X+1. With constant annual births, mortality would normally result in there being fewer persons aged X+1 than X. The ratio at age X to age X+1 should therefore exceed unity; a value much less than unity therefore would indicate the extent of misreporting inherent in the age X. However, it is possible that any preference for age X may be neutralized by an equal or higher preference for age X+1 due to digital preference. Accordingly, the suggested alternative ratio is calculated as at age X to the average at the age with the same digit in the younger and older cohorts. In symbols, the proposed ratio is $P_X / \frac{1}{2} (P_{X-10} + P_{(X+10)})$ ... (1). The ratios derived for Ghana using the relation in (1) above were 1.243 (1960) and 0.867 (1970) for males; 1.526 (1960) and 1.021 (1970) for females; 1.381 (1960) and 0.943 (1970) for both sexes. On this basis, it can be infered that there was a tendency within the Ghanain population to exaggerate the reported age at voting in the 1960 census especially among females; in 1970, excepting for the females, this tendency was considerably reduced.

(iii) Overstatement at older ages

The detection of errors emanating from a distinct overstatement of age among those at very advanced ages is equally easily handled. If for instance persons under 90 at one census report ages in excess of 100 at the next decennial census, the apparent survival ratio for 90-99 would be overstated while that for 80-89 would be understated. The suggested strategy is to compare decennial survival ratios with data at various censuses against those with the corresponding figures for various life tables. If the forward census survival ratio (FCSR) exceeds the corresponding life table survival ratio (LTSR), then this would constitute a sign of exaggerated ages. If persons overstate ages by same amount at each census, the FCSR would be too high relative to the LTSR because the true ages would be less than those shown. This test assumes reliability of LTSRs especially at the older ages and yet the life tables are derived from the census data. Another limitation of the test is the absence of life tables for contemporary African states due to paucity of data. The alternative method suggested for detecting age overstatement among the elderly is even more vulnerable to this lack of life tables. It involves the comparison of the enumerated age distribution with that of a stable population of comparable fertility and mortality conditions.

Table 1: Per cent distribution of children under 5 in Ghana (1960 and 1970) by single years

Age	1960 (N in 000s)						1970 (N 000s)					
	Male		Female		Both sexes		Male		Female		Both sexes	
	N	%	N	%	N	%	N	%	N	%	N	%
0-1	136	21.3	142	21.7	278	21.5	143	18.4	144	18.4	287	18.4
1-2	106	16.6	106	16.2	212	16.4	140	18.0	142	18.1	282	18.0
2-3	128	20.0	130	19.8	258	19.9	159	20.4	160	20.4	319	20.4
3-4	143	22.3	146	22.3	289	22.3	172	22.1	173	22.0	345	22.1
4-5	127	19.8	131	20.0	258	19.9	164	21.1	166	21.1	330	21.1
0-5	640	100.0	655	100.0	1 295	100.0	778	100.0	785	100.0	1 563	100.0

(iv) Unknown proportion

Ideally, assuming an improvement in the level of literacy in the course of socio-economic development, the population proportion reported as unknown should decrease with each succeeding decennial census. The proportion with unknown ages therefore should be computed for various censuses to ascertain the degree of improvement. However such improvement could be spurious depending on enumeration instructions and hence any improve ment may not necessarily reflect increased literacy.

(V) Age heaping

Regarding age heaping (i.e. digital preference) the simplest explanation for its incidence reported in the literature is illiteracy (Ekanem, 1972: 8-21). Simply age heaping is the overrepresentation of persons reporting ages ending in certain preferred digits and a corresponding underrepresentation of persons reporting ages ending in other less preferred digits (Stockwell and Dixon, 1966). Many people in reporting their ages or estimating other peoples' ages, tend to roundoff to the nearest age ending in 0 or 5 either due to ignorance of exact age or some sort of vague tendency toward orderliness.

Several indices have been devised for measuring the extent of digital preference prevailing in the reported data from a given census of population/housing and surveys due to such causes outlined above. Classic examples of such indices are those of Bacchi, Myer's and Whipple's. Of the three, Myers index appears to be the most popular. The smaller this index (i.e. the nearer it is to zero), the more accurate the census age statis tics can be considered in terms of digit preference. The few cases of using the index for assessing the extent of age heaping in the censuses/surveys of African states (Table 2) revealed a range from 9.2 (Botswana, 1971) to 66.3 (Morocco, 1960) among males

and 10.6 (Botswana, 1971) and 86.7 (Morocco, 1960) among females with a mean of 27.4 (males) and 32.0 (females); the corresponding standard deviations being 18.6 and 22.5. One main point is clear from these estimates. Excepting the case of Swaziland (1966), the index indicates that the reported ages for females are more prone to error than those for males. However, Hill (1980) notes that the usefulness of this index should not be exaggerated since it is generally possible to detect heaping by eye without the calculation of indices. In particular, the index should not be interpreted as a measure of the general quality of an age distribution since heaping is only one element of such quality.

The fact is that although the nature of distortions in the age-sex data from African countries has been discussed at length, (Van de Walle, 1968) the phenomenon of digital preference has not been carefully analysed besides the observation that the census data from these African countries reveal a bias on the digits 0 and 5. Indeed digital preference is extremely common in most African data. The extent of the problem can be illustrated with reference to the Nigerian census data of 1963 and the Ghana 1960 census. Table 3 shows for Nigeria the index of digital preference in the form of number of people reported at each digit of age expressed as per cent of total number of people. The pattern of preference, the same for both sexes, consists of very large preferences for digits 0 and 5 in that order. Nearly a quarter reported ages ending in 0 and altogether about 37 per cent of the population reported ages ending either in 0 or 5 which is nearly twice the expected proportion. Table 4 highlights further the extent of the preference for digits 0 and 5 in both the Nigerian and Ghanaian sets of data. The table shows the percentage of people reporting ages ending in 0 and 5 for each five year age group. While the errors in the Ghanaian data are less than those of Nigeria, the pattern is clearly the same.

Table 2: Estimates of Myer's Index, Sex and Age ratio Scores and Joint Score Index for selected African states

Country	Survey Year	Myer's Index M	Myer's Index F	Age Ratio Score M	Age Ratio Score F	Sex Ratio Score	Joint Score Index
Algeria	1954	-	-	8.6	6.8	6.0	33.5
	1966	10.1	19.8	5.3	7.0	5.3	28.3
	1977	-	-	6.0	5.2	2.1	17.4
Egypt	1960			12.0	17.8	7.4	52.1
	1976						93
Libya	1954	-	-	15.4	29.9	16.6	95.0
	1964	-	-	5.8	6.1	7.0	33.0
	1971	-	-	-	-	-	41.0

Country	Survey Year	Myer's Index M	Myer's Index F	Age Ratio Score M	Age Ratio Score F	Sex Ratio Score	Joint Score Index
Morocco	1960	66.3	86.7	24.0	47.9	27.4	153.9
Tunisia	1956	-	-	2.4	1.3	2.1	9.8
	1966	10.0	17.3	6.9	4.8	6.2	30.1
	1975	-	-	-	-	-	28.0
Benin	1961	-	-	17.1	11.6	11.8	64.1
Cape Verde	1970	-	-	9.1	12.0	7.3	42.8
Gambia	1973	-	-	2.1	2.0	2.5	11.6
Ghana	1960	-	-	11.7	15.6	8.5	52.8
	1970	27.0	31.2	9.1	12.0	7.2	42.7
Ivory Coast	1975	-	-	-	-	-	55.0
Mauritania	1976	-	-	-	-	-	29.0
Liberia	1974	-	-	11.4	14.4	11.2	59.3
Mali	1968			8.7	6.2	10.6	48.7
	1976			10.8	20.9	12.4	69.0
Niger	1969	-	-	6.9	7.3	12.7	52.3
Nigeria	1963	52.7	55.8	30.6	37.7	14.2	110.9
Senegal	1960-61	-	-	8.6	10.8	11.7	54.5
	1976	-	-	5.7	14.0	13.8	60.9
Sierra Leone	1974	-	-	13.5	15.2	8.5	54.1
Upper Volta	1961	-	-	15.3	13.0	12.8	66.7
Angola	1960	-	-	8.9	11.0	9.3	47.8
Central Africa Republic	1975	-	-	18.9	26.2	9.7	74.2
Ethiopia	1972/73	-	-	17.4	30.8	24.4	121.4

Country	Survey Year	Myer's Index M	Myer's Index F	Age Ratio Score M	Age Ratio Score F	Sex Ratio Score	Joint Score Index
Kenya	1962	-	-	7.0	5.5	12.4	49.4
	1969	19.3	23.0	4.8	7.5	6.9	33.0
Malawi	1966	-	-	15.1	16.1	5.5	47.6
Mauritius	1952	-	-	7.9	7.4	6.6	35.1
	1962	-	-	7.8	7.3	4.4	28.2
	1972	-	-	8.5	8.2	3.4	26.9
Mozambique	1979	-	-	10.2	14.1	9.1	51.7
Seychelles	1960	-	-	4.3	5.1	4.3	22.4
Tanzania	1957	-	-	2.0	2.6	2.4	11.6
	1967	36.9	41.5	15.8	15.1	11.5	65.5
Uganda	1969	23.6	33.3	9.2	18.7	12.5	65.4
Zambia	1969	14.4	15.8	17.2	9.6	14.9	71.4
Botswana	1964	-	-	11.6	9.0	5.6	37.4
	1971	9.2	10.6	8.3	5.5	9.5	42.4
Lesotho	1966	-	-	14.4	16.4	21.4	95.1
	1976	-	-	9.0	8.9	5.3	33.6
Swaziland	1966	32.4	17.0	21.8	14.9	9.4	64.9
	1976	-	-	-	-	-	11.0

Table 3: Preference for digits of age by sex: Nigeria 1963

Digit of age[a/]	Males % of Total	Females % of Total
0	22.4	23.3
1	8.6	8.5
2	10.3	9.7
3	8.2	8.1
4	7.4	7.4
5	14.4	14.6
6	7.3	7.2
7	7.6	7.4
8	7.2	7.5
9	6.7	6.3

a/ For the digit 0, the value 22.4% males is derived from the sum of the population in single years 0, 10, 20, 30, 40, 50, 60, 70 and 80 divided by total population; for the digit 3, the population in ages 3, 13, 23 ... 83 were summed and divided by total population, etc.

Source: Ekanem, I.I. and Ayeni S., "Models for measuring digital preference in the census of developing countries", Jimlar Mutune, vol. 1, No.2, (1976), Table 1

Table 4: Percentage reporting ages ending in '0' and '5', Nigeria, 1963 and Ghana, 1960

Age groups	Males				Females			
	Terminal Digit				Terminal Digit			
	'0'		'5'		'0'		'5'	
	Nigeria	Ghana	Nigeria	Ghana	Nigeria	Ghana	Nigeria	Ghana
0-4	16.1	21.3			16.2	21.7		
5-9			21.3	22.3			22.8	23.2
10-14	29.7	24.6			24.9	26.1		
15-19			30.9	23.3			29.6	20.8
20-24	40.0	29.5			45.5	30.7		
25-29			41.9	27.7			43.5	28.6
30-34	64.5	45.5			67.9	50.2		
35-39			48.0	32.3			48.7	32.3
40-44	70.9	49.1			73.9	51.0		
45-49			51.8	36.4			52.7	36.5
50-54	74.7	53.8			77.4	54.6		
55-59			41.6	24.5			41.9	23.0
60-64	73.0	60.5			76.6	60.6		
65-69			45.9	39.5			47.2	36.4
70-74	70.6	60.0			74.4	58.8		
75-79			44.0	42.3			45.4	41.9
80-84	72.4	67.7			75.9	66.7		

Source: Ekanem, I.I. and Ayeni S., "Models for measuring digital preference in the census of developing countries", Jimlar Mutune, vol. 1, No.2, (1976), Table 2.

The enormous popularity of digits 0 and 5 is plainly evident. From age 20 digit 0 is much more preferred to digit 5. Because of this differential preference, the conventional classification into quinary age groups is not likely to have removed the effect of the digital preference in the published age distributions. This is because the age group containing the digit 0 would always be relatively "fuller" than the adjacent ones containing digit 5.

22. This effect is more clearly seen in the pattern of the age ratios calculated from the reported age distribution for Nigeria, Ghana and five other African countries. The age ratio for a particular age group is here defined as the number of people reported in one age group per 100 of the mean numbers reported in the two adjacent age groups. These are shown in Tables 5 and 6 for males and females respectively. In distortion free age distributions these ratios for ages between 10 and 70 should all be quite close to 100 and not deviate from 100 by more than 3 (Gardiner, 1960). For Nigeria and Ghana the age ratio pattern is the same. The ratio is well below 100 for each quinary age group containing digit 5 while it is much above 100 for the age groups containing digit 0. This is simply the effect of the differential digital preference between digits 0 and 5. Because of the great preference for

digit 0 than for digit 5, quinary age groups containing 0 are fuller than the adjacent ones containing 5 and for both countries. For the remaining five countries which incidentally are all Francophone, the differential preference between digits 0 and 5 is still highlighted but in the reverse order. The age ratios for age groups containing digit 5 are now about 100 or clearly larger than those for groups containing digit 0. This reversal, which will be called here "the INSEE effect", has earlier been noted by Van de Walle (1968). It is due most probably to the practice whereby in most of the French inquiries interviewers are always cautioned against figures ending in 0. For these countries requisite data are not available to enable the construction of tables similar to the Tables 3 and 4. In addition, as many of the Anglo-phone African countries, it has been observed that inspite of the predominant preference for zero, the age groups with end digits 5-9 are more than those with end digits 0-4 due to the higher preference for digits 6-9 instead of 1-4.

Table 5: Observed age ratios for 7 African countries: Males

Ages	Nigeria 1963	Ghana 1960	Upper Volta 1961	Niger 1962	Senegal 1960-61	Dahomey 1961	Togo 1958-60
15-19	78.6	88.01	96.47	110.31	85.62	82.67	84.92
20-24	123.49	96.85	87.50	82.18	92.95	85.56	89.26
25-29	99.02	109.87	121.88	93.23	115.95	122.45	129.08
30-34	106.97	101.72	81.69	110.44	98.52	84.14	81.27
35-39	78.39	97.06	123.08	105.66	103.97	125.64	122.09
40-44	129.40	103.39	83.64	102.11	86.84	82.17	83.05
45-49	68.54	93.45	121.05	100.65	116.38	116.02	119.75
50-54	142.25	106.31	83.33	90.63	91.01	88.03	89.93
55-59	49.08	74.02	104.00	103.09	103.61	104.97	89.67
60-64	203.70	138.51	90.91	113.04	99.19	86.67	105.22
65-69	51.40	69.35	120.00	-	-	128.35	96.26
70-74	152.70	122.82	83.33	-	-	-	85.60

Source: Ekanem, I.I. and Ayeni S., "Models for measuring digital preference in the census of developing countries", Jimlar Mutune, vol. 1, No.2, (1976), Table 3.

Table 6: Observed age ratios for 7 African countries: Females

Ages	Nigeria 1963	Ghana 1960	Upper Volta 1961	Niger 1962	Senegal 1960-61	Dahomey 1961	Togo 1958-60
15-19	85.24	82.20	87.06	97.16	100.66	80.05	75.63
20-24	131.94	112.94	112.94	79.75	96.40	113.89	113.62
25-29	99.07	107.78	112.94	100.38	129.03	113.67	113.36
30-34	107.97	101.29	87.06	106.61	86.18	91.49	77.60
35-39	68.64	91.55	121.31	105.53	107.95	106.24	114.58
40-44	135.67	105.96	80.00	94.23	84.32	87.35	82.36
45-49	59.37	84.11	121.05	104.35	111.81	109.00	118.50
50-54	159.08	113.49	77.78	93.91	92.91	87.61	86.85
55-59	42.66	71.04	108.33	106.25	91.01	107.06	91.81
60-64	227.80	141.76	100.00	85.71	109.04	90.04	99.29
65-69	47.23	70.31	100.00	-	-	114.08	106.60
70-74	165.08	123.31	88.89	-	-	-	88.51

Source: Ekanem, I.I. and Ayeni S., "Models for measuring digital preference in the census of developing countries", Jimlar Mutane, vol. 1, No. 2, (1976) Table 4.

Besides the observations by Hill noted earlier, it has also been observed that this classical approach to digital preference developed for statistically advanced countries, is useless for the purpose of treating census populations in which considerable error may be present from this cause as it is in contemporary Africa (Ekanem and Ayeni, 1976). This contention is principally explicable in terms of the well known fact that the generality of African population is not used to statistical reporting. In particular, the ages returned for individual at the various national census in Africa are mostly not spontaneous replies from the respondents (who are largely illiterate and ignorant) but represent estimates by the field interviewers (UN, 1967). To remove these biases and errors in the data, graduating formulae have been devised for analysing and correcting digital preference in the Census statistics of developing countries. To date, three such formulae have been used. These include the United Nations Secretariat Index, Newton's formula and the ratio technique proposed by Carrier and Farraq (Ekanem and Ayeni, 1976).

In order to test the adequacy of each of the three graduating models in terms of reducing digital preference in reported age data, Ekanem and Ayeni (1976) applied them to 26 data sets from the census statistics of 13 African countries with pertinent data and their performance was measured by calculating from the graduated age distributions, sex and age ratio scores and joint score index. The co-authors reported that it is possible to achieve substantial reductions in such errors by the use of all three models. For them, both the ratio method and the UN formula are superior to the quadratic method and there is little to choose between the first two methods. Considering the difficulty of using the ratio method without the aid of a computer the co-authors concluded that the UN method seems satisfactory for everyday use.

On the basis of this finding, the Joint Score Index is used here to measure the incidence of digital preference in the past and recent census/survey data of African states with pertinent data (Table 2). In adopting the index, it is noted, as its original authors, that it is not very exact and should be regarded as an order of magnitude rather than a precise measurement. Theoritically the index should approximate zero for a stationary population with constant fertility/mortality and nil migration. For real populations with changes in all three variables, the index should depart from zero and should increase in absolute value as inaccuracies increase in the reported data. The observed index for the 32 countries in Africa with needed data is shown in Table 2. The advantage of these estimates is that the index which is obtained is affected by differential omission of persons in various age groups from the census/survey count and by tendentious age misstatement as well as by digit preference. Each is, therefore, more truly a reflection of the general accuracy of the age statistics than either Myers, Bachi or Whipple's index (UN, 1955).

However, out of the 32 countries with data (Table 2), only in Algeria, Mauritius, Lesotho and Swaziland do the estimates appear to be stable and consistent in the sense that the estimate for each succeeding census/survey date is lower than the earlier estimate consistent with expectations. For all the other countries, the estimates exhibit considerable variations. This raises the question of how reliable is the Joint Score Index in measuring errors in age data. It will be recalled that a measure is said to be reliable if it is stable, dependable, accurate and predictable; it is valid if it is relatively error free. Given the observations just made on the basis of the estimates made for the 32 countries here (Table 2), it is obvious that the Joint Score Index is not a very reliable and valid index for measuring digital preference in the census/survey data of African states and should be used with caution.

As Hill has further argued, the problem with the UN index is that true fluctuations in the age distribution will inflate its value, which will anyway be greater than zero even for a perfectly recorded stable population because sex ratios do change gradually with age and on average, any age group is larger than half the sum of both its neighbours, since mortality increases with age (Hill, 1980). Thus the index may be useful for comparison purposes as used here (Table 2) but not too much should be read into its actual value.

The power of the checks discussed thus far is limited because real age distributions can depart from a regular pattern as a result of fluctuations in fertility in the past, or migration, or disasters such as wars. Consequently, observed oddities can in some cases be real features of the population. When two or more age distributions are available, the checks become considerably more powerful since the failure of a feature at the first census to reappear, lagged by the intercensal interval, at the second census is a strong indication of error.

A convenient way of looking at the consistency of two age distributions is by calculating cohort survivorship ratios. Ratios over 1.0 are unacceptable unless they can be explained by net immigration. Ratios should also fall fairly smoothly as age increases, so erratic fluctuations can be taken as indications of error, as can marked differences in survivorship ratios by sex. Such a procedure has been used with some modification in evaluating the 1963 census age-sex data from Nigeria (Ekanem, 1972) to demonstrate the extent of overreporting the population of certain age groups.

(vi) Other devices

Aside from use of specific indices for identifying content errors in reported age data, Brass has noted four other devices for evaluating and adjusting demographic data in age. These include cumulation, use of reference standards, linearizing transformations and scaling transformations (Brass, 1969: 183-204).

(a) Comulation

The basis of suggesting the cumulation of reported age distributions from censuses/ surveys is that the procedure has the salutary effect of cancelling out erratic fluctuations as it is obvious from Figures 1 and 2. The reported female proportions for Nigeria (1963) in Figure 1 exhibit considerable fluctuations relative to the corresponding cumulative proportions in Figure 2. By implication, such cumulative distributions can be used to detect systematic errors in reported age data.

(b) Reference distributions

The mere detection of systematic errors in age data does not provide a decision on what constitutes an unacceptable divergence from pattern or trend. Such a goal can be achieved if comparison is made with a reference distribution, i.e., a function which is similar in shape to that which describes the measurements. One such recommended function for evaluating reported age-sex data is the use of the stable population model. The method comprises the derivation of a stable age-sex structure based on assumptions derived from the particular population and comparing the latter by age-sex with the corresponding reported data. The derived index of dissimilarity yields some idea of the error in the reported data as is illustrated with data from the 1963 census of Nigeria (Table 7). There were obviously greater distortions in the reported frmale age data of Nigeria at the 1963 census relative to the males.

FIGURE 1: Graph of Reported Vs. Stable age Distribution, Nigeria, 1963 (Females)

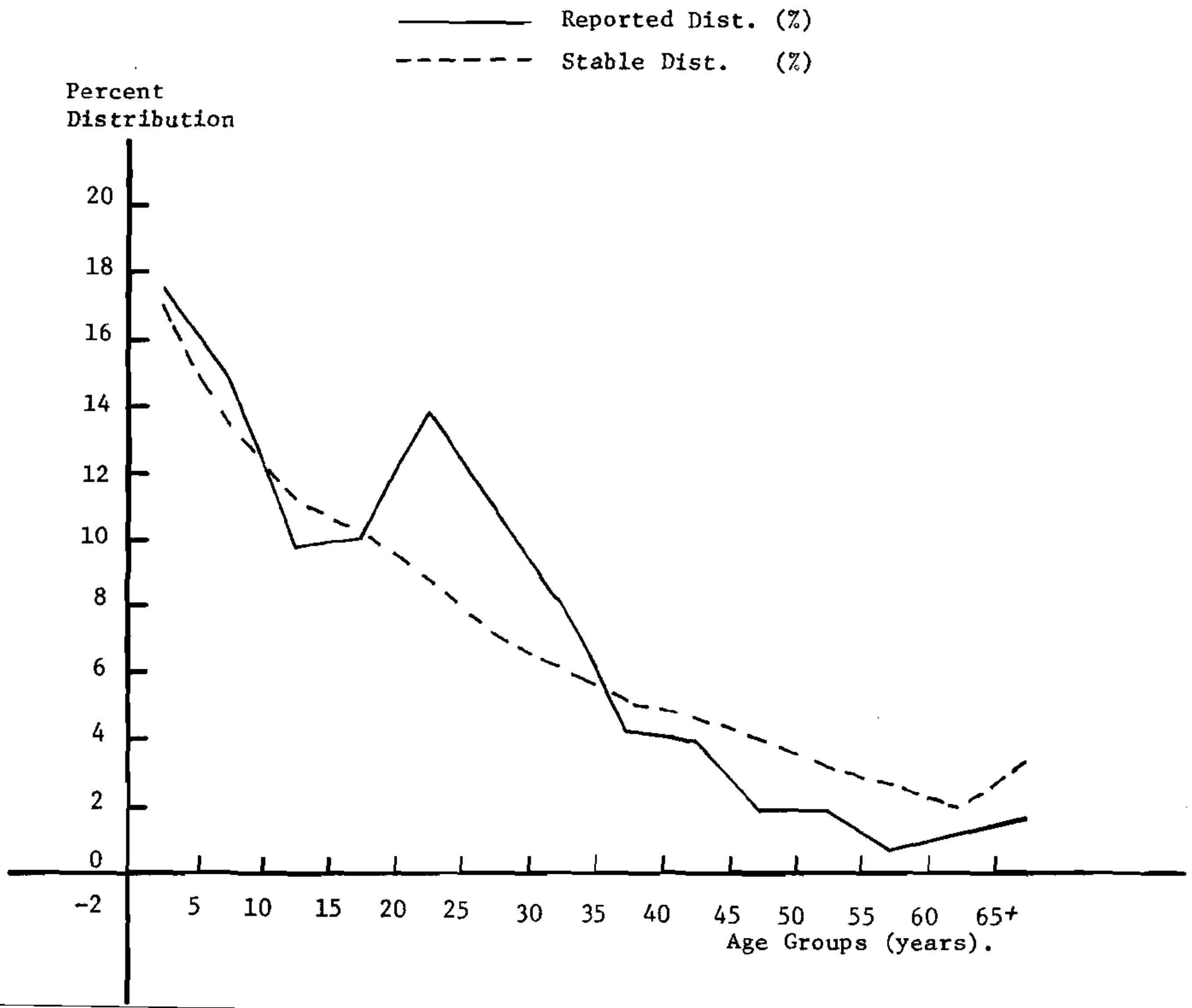
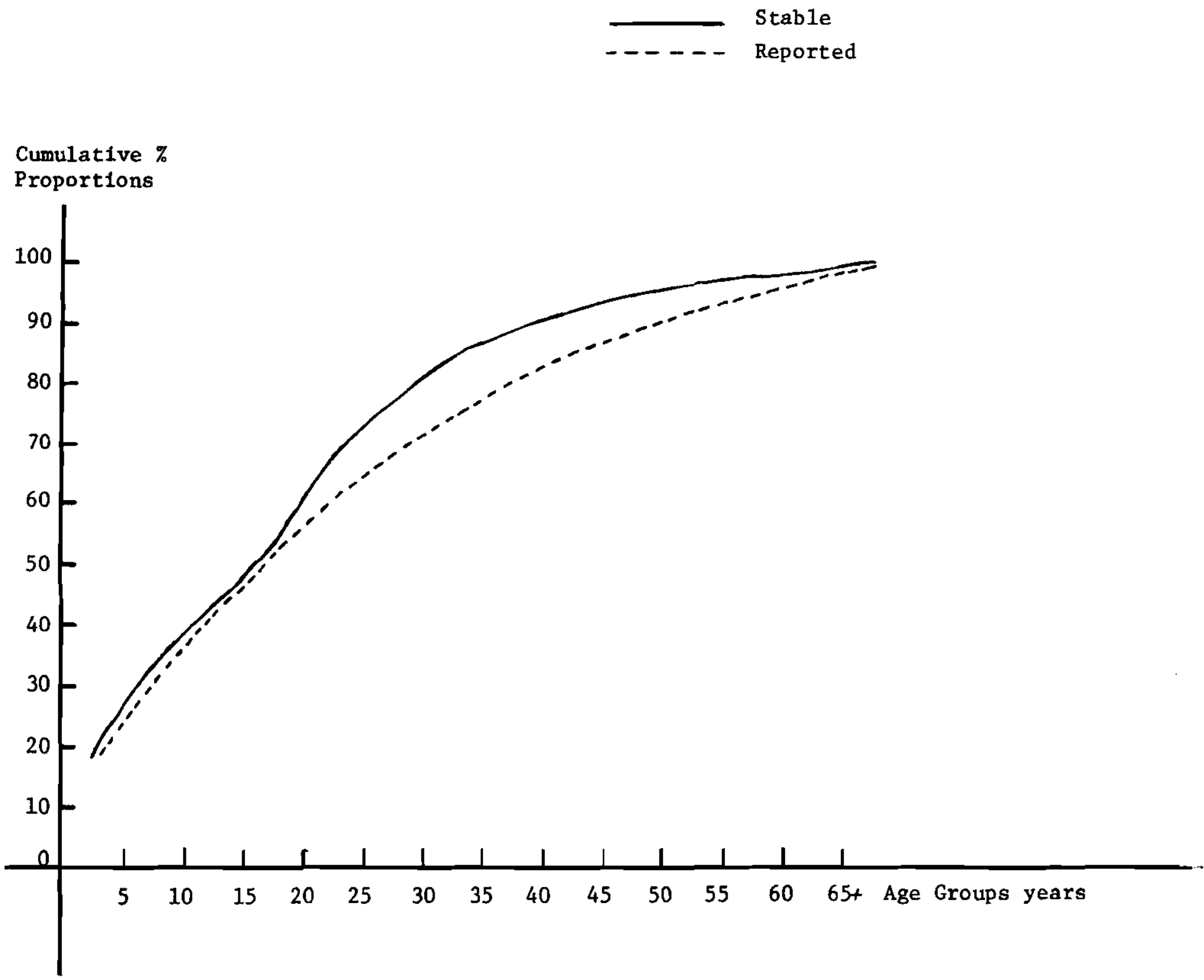


FIGURE 2: Graph of cumulative Reported Vs. Stable Distribution, Nigeria 1963 (Females).



The objective of this approach is not to make the reported age-sex data conform closely to the reference distribution (in this case, the stable population model) but to display the anomalies more clearly and aid in distinguishing between unique characteristics of the population and errors in the data. For instance, Figure 1 indicates that the reported age distribution (Nigeria, 1973) exhibits considerable distortions relative to the stable. In theory a tendency for the deviations to increase with age suggests exaggeration. Other biasses should of course show up as hollows and bumps in the sequence of deviations as in Figure 1 for Nigeria. It may be quite useful to plot male and female deviations on the same graph because deviations introduced by the use of a stable population not exactly representing the true population will tend to appear in both.

One of the problems with this approach is the suitability of the stability assumption vis-a-vis the population in question at the particular moment of analysis. Nevertheless, from an extensive application of the technique to the data from African countries, a pattern of error has been discerned (UN, 1967). The pattern discerned is that, for the generality of African countries, the reported age-sex female proportion in 5-year intervals exhibits the following characteristics relative to the stable: the proportion 5-9 is above the stable; the proportions 10-14 and 15-19 are below the stable; and the proportions 25-29, 30-34 are above the stable. It is, therefore, useful to ascertain if the error pattern from a particular country conforms to the general pattern. In this regard we recall the application of the technique to the 1963 Nigerian census data (Table 7). The conformity with the general pattern in the latter case was used as a basis for arguing against the complete rejection of the results from the 1963 census of Nigeria (Ekanem, 1972), although the possibility remained that conformity with the general pattern could rather reflect the inadequacy of the stable population model in the particular context.

Another example of reference distribution is the Carrier Farrag (1959) Ogive for examining proportional cumulative age distributions applied by the co-authors to the 1947 census data of Egypt. This reference standard is a function which changes linearly from zero at birth to agree with the observations at age 60 years. As in the illustration with the stable model, the subtraction of this from the observed age distributions gives a set of differences whose variations can be better appreciated. Other reference distributions could be mathematical or empirical, a general standard or one specific to a particular situation. A case in point is a reference distribution derived from other data for the population under study such as the use of fertility rates from retrospective reports at a census as a standard for disciplining birth registration records.

(i) Linear transformations

Analytically the differences between the cumulative proportions under given ages observed and for the standard can then be graphed against the reference values. This is illustrated with female age data from the 1963 Nigerian census (Figure 3). Adjusted female age population distribution for Nigeria (1963) can easily be derived by drawing a smooth curve through the points. Brass notes that although such a curve can be drawn through

Table:7: Reported (R) versus stable (S) age distributions for Nigeria, 1963

	Males			Females		
	R%	S%	/R-S/	R%	S%	/R-S/
0-4	16.8	17.8	1.0	17.6	17.0	0.6
5-9	15.5	14.0	1.5	14.8	13.5	1.3
10-14	11.6	12.0	0.4	9.7	11.6	1.9
15-19	8.9	10.3	1.4	10.0	10.1	0.1
20-24	11.2	8.9	2.3	13.7	8.7	5.0
25-29	9.3	7.5	1.8	10.8	7.5	3.3
30-34	7.5	6.4	1.1	8.0	6.5	1.5
35-39	4.8	5.4	0.6	4.1	5.5	1.4
40-44	4.7	4.5	0.2	4.0	4.6	0.6
45-49	2.4	3.7	1.3	1.8	3.9	2.1
50-54	2.4	3.0	0.6	1.9	3.2	1.3
55-59	1.0	2.3	1.3	0.7	2.6	1.9
60-64	1.6	1.7	0.1	1.2	2.0	0.8
65+	2.4	2.5	0.1	1.7	3.3	1.6
Index of dissimilarity[a/]			6.9			11.7

a/ Index of dissimilarity is here defined as one-half of the sum of the absolute deviations of the reported from the stable proportion (for each age group).

Source: The reported age structure is derived from the Population Census of Nigeria, 1963, vol. 3, p. 7; the stable age structure is based on assumed o^{e}_{e} = 40 (females) and C(15) = 43.8% (males) and 42.1% (females and is derived from the North model tables, Regional Model Life Tables and Stable Population, Princeton (1966).

FIGURE 3: Differences between standard and observed % under ages, Nigeria 1963, Females

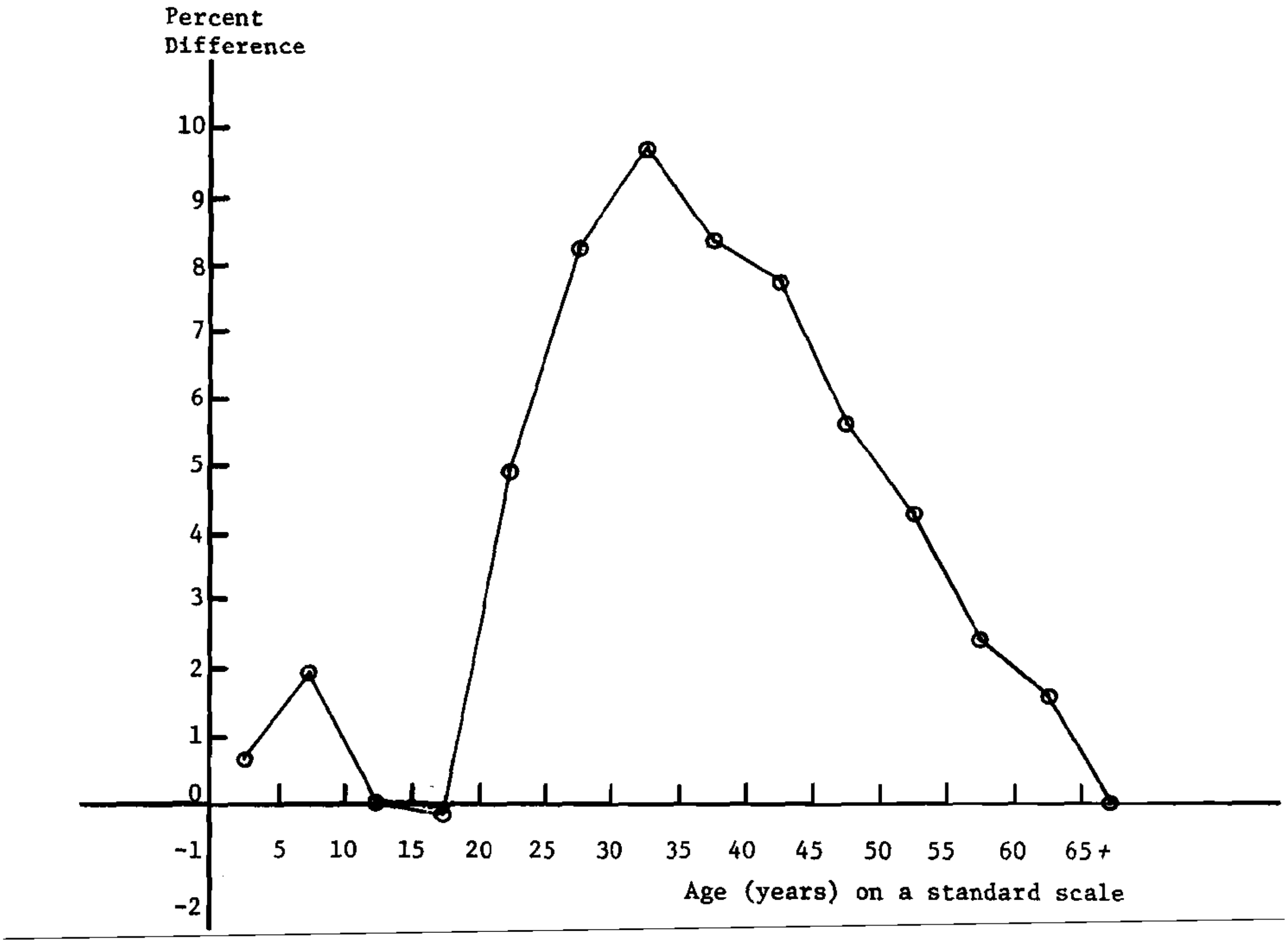
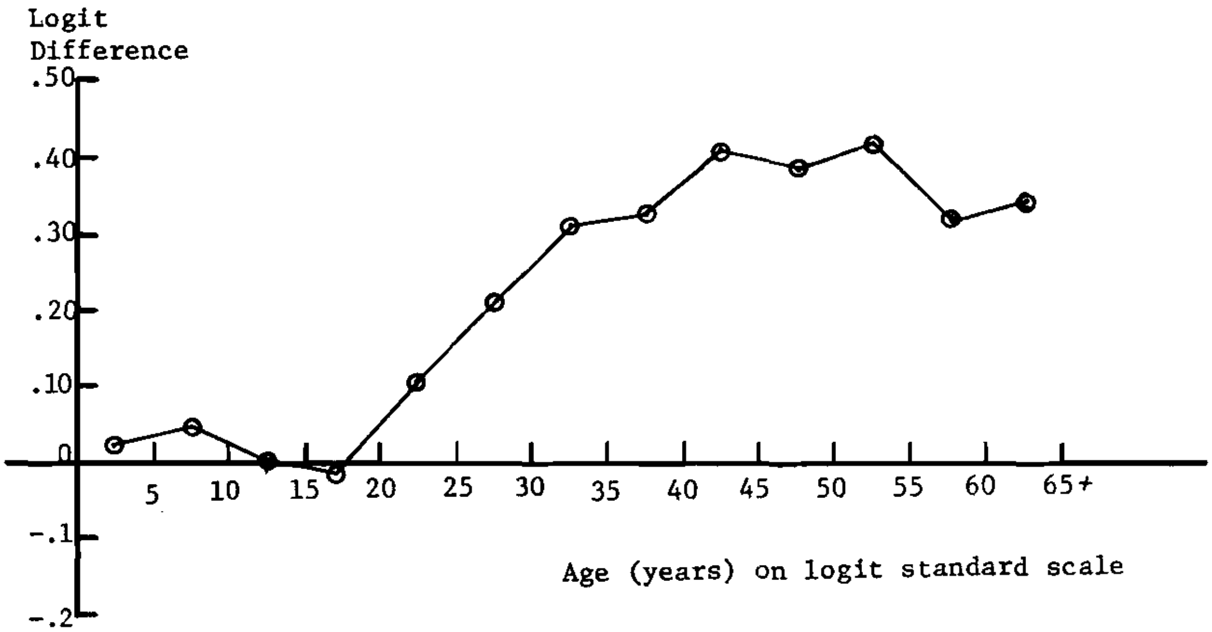


FIGURE 4: Differences between logits of standard and observed % under ages, Nigeria 1963, Females.



the points, objective methods of fitting points are more effective when data are transformed, i.e. if a function which brings the plotted relationship closer to a straight line can be found. The logit appears to be the most useful of such transformations. Figure 4 shows the difference between the logits of the stable and observed cumulative age distributions for Nigeria (1963) plotted against the transformed reference standard. (Both series (i.e. logits of the stable and observed cumulative age distributions) are derived from Table 7). Unlike the untransformed values in Figure 3, the points in Figure 4 are closer to a straight line and the age distribution can be adjusted much more readily. The transformed values (Figure 4) clearly illustrate the point that the 1963 Nigerian female age distribution was far from being smooth

On the whole, to the extent that pictorial representations are more focussed in terms of enabling the mind to perceive deviations from expected values, these devices suggested by Brass appear more relevant than the age accuracy indices discussed earlier. However, although they appear more handy and usable in this particular context, the devices are not necessarily more reliable because they involve models which can introduce errors if the pattern of mortality is unknown or there had been past fluctuations in mortality. (A stable population distribution assumes constant mortality and fertility levels.

V. ERRORS IN CURRENT AND RETROSPECTIVE FERTILITY DATA

Among other things two basic questions are normally asked of women aged 15+ in censuses/surveys, i.e. the number of children ever born alive by them (retrospective fertility) and whether they have had a live birth in the 12 months period prior to the census/survey (current fertility). When both pieces of information are available by age of the women, it is possible to derive reasonable estimates of fertility by comparing the most reliable features of the two sets of data and then adjusting both the current and retrospective estimates. Both pieces of information on life time fertility are the most important census/survey data concerning fertility and hence need to be appraised carefully.

Hill has summarized the various analytical techniques for evaluating such data:

(i) examine the frequency of non-response by age group. A high level of non-response for all age groups from 15-19 to 45-49 suggests that the data may not be good;

(ii) calculate the mean CEB in each five year age group from 15-19 to 55-59. Unless fertility has been rising, the average parities (P_i) should rise smoothly to a plateau for the age groups 45-49, 50-54 and 55-59. If the average parities reach a peak for a younger age group and then decline, there has almost certainly been some omission of CEB from the reports of the older women;

(iii) calculate a rough and ready test for such omission by estimating the total fertility rate (TFR) from the relations.

(a) $TFR = (P_3)^2/P_2$ (see UN, 1967: 31-36)

(b) $TFR = P_2\ (P_4/P_3)^4$ (see, Brass and Rachad, 1979)

Brass and Rachad (1979) suggest that the TFR should be estimated in both ways and the lower of the two estimates taken. If the TFR obtained in this way is substantially higher than the average parities for women 45-49 and over, these women have in all probability omitted children from their reports.

(iv) Compute sex ratios at birth per parity. These ratios should be in the range of 1.02 to 1.07 and should not show any trend by age although the value for the women aged 15-19 often differs from the others; any deviations would indicate errors either of classification of CEB by sex or of differential omission by sex;

(v) Comparing the observed average parity distribution with those predicted by fertility models such as the relational Gompertz model of fertility. Strictly speaking, this model is a mode of cohort fertility and may not fit cross-sectional average parities particularly well (Brass and Rachad, 1979). However, fairly steady changes in fertility over time would not affect the detection of error very much.

Besides, the foregoing methods, the argument in contemporary demographic literature is that the reported current fertility contains errors emanating from the factor of "time imprecision"; the retrospective fertility also contains errors due to the "memory lapse" factor (Brass, 1975). The P/F technique developed by Brass is often used to detect the errors in both current and retrospective estimates. The ratios (P/F) show a variation with age; they are greater than unity at the youngest ages and less than unity at older ages. By implication if the results for the younger ages are close to unity, they indicate that data on current births are consistent with the data on retrospective fertility - suggesting that the current fertility data have been collected with some degree of precision and hence are relatively reliable. If the data show a gradual decline with age, this can, in the absence of an alternative explanation, be interpreted as a memory lapse phenomenon. Any market deviations from both expectations (i.e. P/F exceeds unity at younger ages; P/F decline gradually with age) would suggest errors in both current and retrospective data.

These points are illustrated with the data on P/F ratios for three African states. Theoritically, these ratios should be close to unity if there is agreement between both measurements. From Table 8, the data for Chad appears reasonable as it meets the above desiderata. The data for Uganda is relatively poor given the sudden drop from P_2/F_2 to P_3/F_3. In the case of Nigeria, the distortions are really marked.

Table 8

P/F ratios for selected African states

Age groups	Chad a/	Uganda a/	Nigeria b/
15-19	1.05	1.36	2.73
20-24	1.06	1.13	1.26
25-29	0.97	0.89	1.09
30-34	0.94	0.79	1.04
35-39	0.93	0.74	1.03
40-44	0.89	0.71	1.05
45-49	0.93	0.72	1.07

Source: a/ Brass, W. (1975), op. cit., p. 15, Table 1;
b/ Results of the 1971/73 National Fertility, Family and Family Planning Survey of Nigeria.

The questions have been raised if the P/F ratio technique functions well in application; how is the success of the technique to be judged; why does the method sometimes fail? There have been no clear cut answers to these questions. Several operational problems militate against the efficiency of this technique including age misstatement; a tendency for older females to report fewer children ever born; the fertility experience of surviving women may be different from those who fail to survive; when fertility is changing, it is particularly difficult to estimate. Accordingly, values of the P/F ratios should be

carefully scrutinized in the light of what is known about the population. Where the technique appears to fail, use of information on parity may shed light on errors present. This will be illustrated here with data for South/Western Nigeria (1971).

In Table 9, data is presented on a distribution of the cohort period specific fertility rates (per 1000) of the 5, 214 women aged 15-49 and interviewed in South Western Nigeria during the survey of the area in 1971. The general picture that emerges from the data is that in South Western Nigeria fertility was increasing since 1922 until about 1966 when it started to decline The question can be raised as to how reliable and valid are the results in Table 9 in terms of measuring fertility change in the study area.

For Porter (1979) one way to check on the apparent pattern of fertility decline in the study area in the most recent period (0-4 years before survey) is to examine for the prevalence of "event misplacement". From the data (Table 9) the older cohorts of women seem to report older cohort fertility. By implication there is need to caution against the inference of a declining fertility in the study area since the data amay contain other errors besides omissions. Som's (1973) view is that certain vital events (e.g. female births and births of children who died in early childhood) are subject to a higher probability of omission than others. According to Porter a possible test for the prevalence and pattern of omitted live births as reported by the South Western Nigerian women would be to check for both phenomena. If female births were subject to differential omissions, the reported sex ratios (by age) for these live births would exceed their expected values. From the point of view of the reliability and validity of the reported live births, if this pattern is not readily discernible from the reported data, it could be an indication of the "degree of confidence", which the analyst can have in the data. A distribution of such sex ratios is presented in TAble 10.

According to Van de Walle (1968), sex ratios at birth recorded in African surveys are under unity as often as above. From the data which he examined for selected regions of Africa, sex ratios were under unity in 53 per cent of the cases at birth; 91 per cent of the cases under one year; and, 83 per cent of the cases for the age group 1-4 years. The reported age group 5-9 presents everywhere in Africa (except the Congo) a sex ratio above unity. For former French colonies in Africa, sex ratios are characteristically above unity between ages 10-14 and under unity between ages 20-40. Although Van de Walle argues that the actual trend of sex ratios by age cannot be deduced precisely from available data, the sex ratios in Table 10 deviate rather markedly from the several situations observed in most of Africa for ages 10 and over. In the age group 5-9, the pattern is consistent with expectations. For the 0-4 age group, excepting the case of the surviving live births aged zero, the reported sex ratios deviate again from the generally observed pattern. The general picture portrayed by the data in Table 10 is that the reported live births were possibly affected by differential omissions of females. By implication, the apparent fertility decline in the 0-4 years period before survey (Table 9) may reflect both this differential ommission of female births, the prevalence of "event misplacement" and a possible fertility decline.

Table 9

Cohort-period-specific fertility rates per 1000 women

by time period in Southwestern Nigeria (1971)

Age of mother at survey	Total births per 1000 women in five years period before survey								Number of women in total sample
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	Total	
15 - 19	182							182	815
20 - 24	783	307						1 090	1 052
25 - 29	1 131	1 028	313					2 472	1 231
30 - 34	1 103	1 403	926	301				3 733	866
35 - 39	836	1 256	1 322	862	263			4 539	574
40 - 44	598	1 018	991	1 016	209	209		4 430	440
45 - 49	364	890	1 144	1 131	1 030	733	246	5 538	236
15 - 49	4 997	(5 902)	(4 696)						5 214

Table 10

Distribution of sex ratios by age of the children as reported by Southwestern Nigeria women, 1971

Age of child	Surviving children sex ratios[a]	Dead children sex ratios[a]	All children sex ratios[a]
0 - 4	113	103	112
5 - 9	104	113	107
10 - 14	116	114	115
15 - 19	138	138	138
20 - 24	135	139	130
25 - 29	139	119	129
30 - 34	181	150	174
0 - 34	114	114	114

(a) Sex ratio at birth for all children was 102 (male = 536; females = 328) as against 99 (males = 311; females = 313) for the surviving children.

The question then is, if fertility has not been declining in Southwestern Nigeria in recent years. What pattern has fertility been following? The other two alternative possibilities are an increasing or a constant pattern. The former appears unlikely for obvious reasons. As in other parts of Nigeria, families in Southwestern Nigeria have recently been experiencing a change from the traditional large family norm in the face of a declining infant and child mortality. Thus the children are no longer looked upon as old-age security. With the interaction of the rapidly increasing middle class with Western ideas, the children themselves are raising questions having to do with their education and their future. Besides, the practice of polygamy is fast on the decline. These three factors - a declining infant and child mortality, the rising cost of education, and the trend towards a change in family struvture are among the factors which have been militating against the traditional large family norm in most parts of Nigeria. All these tend to suggest a constant fertility in the study area given the doubts regarding a declining pattern.

Brass (1975) has suggested a method of using parity information to check for a possible constancy in fertility. This consists of computing the Brass P/F ratios but using first births as against all births. Such data is presented in Table 11 where f_i, 1 are the age-specific first-birth rate and represent the ratio of the number of first births by age to the number of women in the age group. Accumulation of these f_i, 1 values yields F_i, 1 which is comparable to the proportion of women who become mothers at any time in a longitudinal analysis. The F_i, i values represent the proportion of women by age with one or more children. Similarly, F_i, 2 refer to second parity children. The P_i, 1/F_i, 1; P_i, 2/F_i, 2 ... etc., are similar to the P/F ratios for all births. In relation to all birth P/F ratios (Hill, 1979), first birth ratios are more sensitive to changes in age at marraige, less sensitive to changes in marital fertility, and generally less variable with age; otherwise they can be treated similarly. Accordingly, Brass argues that if fertility is constant, these P and F values should be related to one another for each birth order. This implies that the ratios should be fairly identical. The fact that this is not the case with the data in Table 11 also raises questions regarding the presumption of constant fertility in Southwestern Nigeria.

Table 11: Data for first births from Southwestern Nigeria (1971)

Age group of women	Parity One			Parity Two		
	F_i,1	P_i,1-	P_i,1/F_i,1	F_i,2	P_i,2-	P_i,2-/P_i,2
15 - 19	.10	.15	1.50	.02	.05	2.05
20-- 24	.48	.63	1.31	.24	.35	1.46
25 - 29	.77	.80	1.04	.53	.68	1.20
30 - 34	.85	.82	0.96	.69	.70	1.10
35 - 39	.88	.86	0.98	.76	.82	1.08

In general, the P/F ratios provide an enormous amount of information about the consistency of the reports of lifetime and recent fertility and also often give indications of the nature of errors present in the reports. If the two sets of information were consistent, the ratios would be equal to 1.0 for each age group. If the ratios are more or less constant by age, but are not equal to one, the age patterns of fertility implied by the two sources are consistent, but their levels are not. If the ratios for early age groups (up to 35) are more or less constant though not necessarily equal to one, and then fall systematically with age, CEB are probably being omitted by older women to a greater extent than by younger women. If the ratios are greater than 1.0, the recent fertility reports may be too high. And finally, if the ratios rise with age, fertility may have been declining in the recent past.

However, from the foregoing, it appears that contrary to expectations, the use of birth histories does not infact overcome the problems posed by use of the P/F ratios in terms of detecting errors in current/retrospective fertility data. The problems confronting analysts of birth history data are basically omitted events; the representativeness of the sample; misreporting the data on occurence of a given pregnancy; misreporting the age of the mother; and, difficulty of obtaining a distribution of the livebirths who died before the survey by years before survey and age of mother in cases where age at death (or year of birth of the dead child) is unknown. By implication, estimates of fertility based on current/retrospective reports from surveys should also be treated with caution.

VI. ERRORS IN DEAD CHILDREN DATA

Because the number of children dead depends on the timing of lifetime fertility as well as child mortality risks, its behaviour is more variable and less easy to model than the number of CEB. Among the few consistency checks (Hill, 1979) on the data re the following:

(i) Calculate mean number of dead children by age group of women. Calculate also the proportion of dead children among those ever born per age group of the women. Both proportions so should increase steadily with age of the women. If either series fails to increase, or declines, as age increase, dead children have probably been omitted from the women's reports to a greater extent than living children.

(ii) Calculate the proportion of dead children by sex among those ever born per age group of the women. Sex differentials in child mortality will result in different proportions dead by sex of child, but the differences should not be large and they should not change very much by age group. A tendency for the proportion dead of female children ever born to increase more slowly than that of male children suggests that dead females may have been omitted to a greater extent than dead males.

(iii) Estimate child mortality probabilities (q_i values) from any of the various methods (Brass, Sullivan or Trussell). The original Brass procedure is the most useful for this purpose. The conversion of each q_i into some index of mortality makes it possible to assess the consistency of the basic data. If the reports of older women indicate lower mortality risks than those of the younger women, the presumption of omission of dead children from the reports of the older women is strong.

(iv) Comparison of levels of child mortality estimated in (iii) above with other estimates of child mortality. The average number dead of the CEB by a cohort of women can only increase as the cohort ages. Thus, if the average number of dead children per woman by age group can be calculated for two points in time, the consistency of the two data sets can be looked at by computing the increase in the average number of children dead by age group for a cohort of women experiencing both intercensal fertility and intercensal child mortality rates.

Besides the foregoing procedures and as with the P/F ratio technique, the method developed by Brass for generating a life table indirectly from survey reports of number of children ever born alive and those surviving can be used to detect errors in the reported data. It will be recalled that the method consists of the following steps (see Brass, 1968: Chap. 3).

(a) Calculation of proportion of deceased children out of children ever born (denoted D_i);

(b) Calculation of q_i values from the D_i values using the Brass multipliers;

(c) Computation of other q_i values (i.e. q_{25}, q_{30} ...);

(e) In order to generate a life table on the basis of the q_i values obtained in step (b), Brass suggests the ploting of the logit values of these q_i values against the corresponding values from the (African standard) Life Table. A smooth line is then fitted to these pair of logit values using the group average method. The use of this approach in fitting the line as against the normal least square method is predicated on Brass' contention that errors in the reporting of children ever born (and those surviving) are not random (as implied by the use of the least square analysis) but are systematic in the sense that the younger women (20-29) are likely to report these events more accurately than the older women (30) given the factor of recall lapse. Brass then gives two conditions which, if both are fulfilled by these sets of points, enable one to use the fitted line as a basis for constructing a life table. First, the slope of the fitted line should fall within the range 0.8 and 1.20; second, the correlation coefficient between the two sets of logit values should be considerably high (at least 0.9). If these conditions are met, then the equation of the line can be written in the form:

$$\text{logit } l(x) = A + B \text{ logit } Ps(a) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where A = intercept of the line on the Y-axis
B = slope of the line
logit Ps(a) = values from the African Standard Life Table

Using the table of the logit transformation function, the l(x) values in equation (1) are obtained. If the chosen radix of the life table is 100,000 then from these values of l(x) the corresponding values for l(1), l(2), l(3), l(4), l(5), l(10) .... l(85) are readily deduced.

(e) Computation of other columns of the Life Table: (i.e., L_x, T_x and e_x): The necessary steps for obtaining these values are described in Barclay (1966).

(f) Alternative method for obtaining the q_i values: In the event of the reported data not meeting the two conditions just outlined, Brass suggests that a model life table be constructed that uses l(2) or l(3) from the retrospective data and has a value of unity in the logit transformation of the African Standard Life Table. If l(2) is used, then from the relation in equation (1)

$$\text{logit } l(2) = A + B \text{ logit } Ps(2) \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

since logit l(2) and logit Ps(2) are known, A is readily deduced. This is then fed into the equation (1) and used to obtain values of l(1), l(2), l(3), l(4), l(5), l(10) .... l(85). These later values are then used to generate the remaining columns of the life table as described in step (e) above.

It follows that if the two conditions described in step (d) above are not met, then the reported data on CEB probably contains errors. The alternative procedure, though analytically tenable, appears synonymous with the imposition of the "African standard model" developed by Brass on the actual situation. As in the case of fertility, the resulting estimates of mortality should be used with caution. Even when the two conditions are met, the analyst should note that any factors affecting the $q_{(i)}$ values derived in step (b) above will invariably effect the estimated values of the life table. Brass argues that the main sources of error in q_i are selective non reporting of dead children, age misstatement of mothers, changing fertility/mortality and the tendency to understate the number of CEB.

An illustration of the foregoing procedure with an empirical situation would underline the point being made here regarding the probably errors in mortality estimates based on retrospective fertility responses of women in childbearing ages. In TAble 12 data is presented on the correlation coefficient, beta and alpha estimated for Southwestern Nigeria as derived from the 1971/73 National fertility, family and family planning survey. As it is obvious from the table, the two conditions were met only in about half the six areas.

Table 12

Relevant values of correlation coefficient, Beta and Alpha from data for Southern Nigeria, 1971-73

Area	Sex	Rank order Correlation Coefficient	Beta Value	Derived Alpha using Beta = 1	Estimated life expectancy at birth (years)
South West Nigeria (U)	M F	.86 .86	1.91 1.91	.215 .220	50.6 50.8
South West Nigeria (R)	M F	1.00 1.00	1.50 1.50	.107 .107	47.2 47.0
All South West Nigeria (U + R)	M F	1.00 1.00	1.68 1.68	.154 .150	48.7 46.6
East Central State (U + R)	M F	.93 .96	1.07 0.91	- -	41.5 45.5
South Eastern State (U + R)	M F	.68 .79	0.68 0.80	.288 -	56.0 50.8
All Eastern Nigeria (ECS SES)	M F	.93 .96	1.20 0.80	- -	40.4 47.5
All Southern Nigeria S.W. + ECS + SES	M F	1.00 1.00	1.60 1.46	0.142 0.154	48.3 48.7

N.B.: U - Urban
R - Rural
ECA - East Central State
SES - South Eastern
SW - South West

Source: Ekanem, I.I. and Faroog, G.M. "The dynamics of population change in Southern Nigeria", GENUS, Vol. XXXIII, No. 1 - 2 (1977).

Again there are no clearcut answers to these questions. The point to bear in mind is that whether or not the two conditions are met, if the pattern of estimated life expectancy at birth was consistently such that the male life expectancy at birth exceeded that of the females, one could argue in favour of the unique African mortality situation. To the extent that the pattern is not consistent, it is probable that either the estimation procedure is not sufficiently reliable or there are clear errors in the data as reported. It is difficult to be definitive in this regard.

VII. ERRORS IN PLACE OF BIRTH DATA

To date there are no reported analytical techniques for detecting errors in place of birth data used in migration analysis. Only the sources of errors in the data have been indicated simply for purposes of cautioning the user. It has been observed that the question on place of birth allows identification of the numbers of people who were born abroad or are citizens of another country, but they do not identify when they came to the country where they were enumerated (Shyrock, 1964). They do not identify patterns of flow that are related to a specific period. Many people who are identified by these data as international migrants may have been in the country where they were enumerated for most of their life. They may even be children of migrants and through this have citizenship of another country, though they may never themselves have been there. In general terms, data on stocks of foreigners or aliens identified by questions on citizenship in African censuses may present a misleading impression of the extent of relatively recent international migration.

It is also noted that the place of birth data could indicate the number of persons bor in and outside the country of enumeration. Those born outside are supposed to be immigrants and those born in the country are assumed to be non-migrant resident population. However, of the persons born outside, some could possibly be nationals of the country under consideration; of those persons born in the country, some could have been children of immigrant parents who hold foreign nationality. Although these two forces operate in opposite direction in the determination of migration status of a person, wrong inclusion in the former is unlikely to counterbalance the omission in the latter, because in Africa many studies show that omissions of such persons exceeded wrong inclusion of migrants (ECA, 1977). Even if there were a quantitative balance in the omission and wrong inclusion of international migrants, some aspects in the study of international migration (such as the causes and consequences) would be greatly affected. Thus, place of birth data coupled with nationality (or ethnicity) could produce some information on the actual immigrants, returnees, persons born outside but hold nationality of the country of enumeration, and persons born in the same country but hold foreign nationality.

As a source of international migration data, the use of birthplace statistics has also been criticized because it relates to a more remote data than does the usual migration questi regarding residence at a fixed past date and hence there is more lack of knowledge on the part of respondents other than the person himself, the statistics do not take account of intermediate moves between time of birth and time of the census or of international migrants who have died; and, persons who have returned to live in their state of birth appear as

non-migrants (ECA, 1977). Although these and other limitations of place of birth data have been discussed elsewhere, nevertheless, place of birth data (when available) can still fill important gaps in our knowledge about international migration in a given country. They provide a broad historic picture of the main geographic migratory movement within the country.

VIII. CONCLUSION

It is impossible in a paper of this kind to cover all the analytical techniques for content error evaluation of demographic data. Only a few of the techniques used in appraising data on age, number of children ever born and number of dead children have been discussed. In the case of place of birth data, only the inherent errors are indicated as there are as yet no well defined techniques for their evaluation. Where data are available. some of the outlined techniques have been illustrated with actual examples. For most of the techniques, data paucity does not permit a thorough grasp of how these methods work in actual cases. It is hoped that as the data situation improves, it should be possible to put these other techniques to test as well.

Regarding errors in age-sex data, the five main sources of error as outlined by Myers have been discussed at length together with illustrated examples. However, for some of the techniques, the lack of national life tables of reasonable accuracy has been the main bottleneck in terms of actual testing of the suggested procedures. The additional devices suggested by Brass for appraising errors in the reported age-sex data are also highlighted. It is noted that neither the series of indices implicit in the Myers' procedures nor the devices by Brass can in fact be preferred to the other in terms of yielding more reliable and valid results. They are all analytical techniques to guide the user of the data of the probable errors in the data.

The same is ipso facto true with respect to the techniques suggested for appraising data on reported number of CEB and those dead. For reasons indicated, there are more numerous and sophisticated techniques for appraising data on CEB than on dead children. Only a few of these techniques have been discussed in this paper for reasons of space. In the particular case of the technique by Brass for generating a life table from information on CEB and number dead out of the CEB by age of mother using the logit transformation function approach, it should be noted that besides the illustration with the Nigerian data (1971/73), its application with data for Central African Republic (1975), Zambia (1969), Swaziland (1976) and Malawi (1977), yielded estimates of life expectancy at birth that were not completely plausible at least in all the cases relative to similar estimates by other methods (see item 5 of Notes). The difference between both estimates was really marked in the cases of Central African Republic and Malawi.

Accordingly, both sets of techniques for appraising CEB and dead CEB, as in the case of age-sex data, point to the need for the establishment of viable vital registration systems in all the countries as well as the intensification of efforts directed at ensuring

sound traditions of census taking in these states. Of course the development of census traditions and vital registration systems in these countries will not render the use of these analytic techniques obsolete since the need to caution the user of the degree of reliability and validity implicit in the data will still be essential. The point is that with good census and vital registration data base, the user's confidence in the estimates derived from the demographic data from the various censuses of population-housing and surveys data would increase when the techniques would reveal less errors in the published data.

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TECHNIQUE ANALYTIQUES D'EVALUATION DES ERREURS DE CONTENU

R E S U M E

L'objectif premier de cette étude est d'indiquer et autant que possible tester empiriquement certaines des techniques analytiques d'évaluation des erreurs de contenu dans les données démographiques. Quatre séries de données démographiques font l'objet d'examen : l'âge, nombre d'enfants mis au monde, nombre d'enfants décédés parmi ceux mis au monde et lieu de naissance.

Pour ce qui est de l'âge, parmi les principales formes d'erreurs de contenu mises en relief figurent la déclaration de chiffres sous-estimant la population de moins d'un an, la tendance à donner un âge exact dans quelque but juridique, une surrestimation nette de l'âge pour les groupes d'âges avancés, la proportion déclarée d'âge inconnu et la tendance à arrondir l'âge. Une analyse des techniques indiquées pour évaluer les erreurs provenant des trois premières sources fait ressortir que l'absence de tables nationales de mortalité assez précises est le principal obstacle à un contrôle véritable des méthodes suggérées.

Quant à la tendance à arrondir l'âge, des divers indices mis au point afin de la déceler, ce sont l'indice de Myers et l'indice des Nations-Unies qui ont reçu la plus grande diffusion. L'emploi de ces indices indique que les données déclarées sur l'âge des femmes des pays africains subissent plus de modifications que les données correspondantes concernant les hommes. Les moyens supplémentaires suggérés, par Brass-accumulation, répartition par comparaison avec une distribution de référence et transformations linéaires - pour mesurer les erreurs dans les données relatives à l'âge et au sexe ne donnent pas de résultats plus fiables et plus valides. Ces ensembles de techniques sont tous deux analytiques et ne visent qu'à prévenir l'utilisateur contre les erreurs probables inhérentes aux données.

Les diverses techniques d' évaluation des erreurs dans les données sur la fécondité rétrospective englobent l'examen de la fréquence de la non-déclaration, de la lente progression attendue dans les parités moyennes vers la stabilisation à une tranche d'âges de 45 à 49 ans, l'estimation de l'indice synthétique de fécondité, des taux de masculinité à la naissance et la comparaison de la répartition des parités correspondantes fondées sur des modèles. Contrairement au cas de la fécondité rétrospective, il existe moins de techniques d'évaluation de la qualité des données concernant les enfants décédés. A ce jour, on n'a pas connaissance de méthodes analytiques permettant de détecter les erreurs dans les données sur le lieu de naissance. En conséquence, seules les éventuelles causes d'erreurs dans ces dernières données figurent dans la présente analyse, l'objectif étant de guider l'utilisateur des données.

Dans l'ensemble, les lacunes des techniques actuelles évaluation des erreurs dans les quatre séries de données indiquent qu'il est nécessaire de mettre en place des systèmes viables d'enregistremnnt des faits d'état civil dans tous les pays africains ainsi que d'itensifier les efforts destinés à assurer de solides recensements dans les divers pays africains.