Overview of Census Evaluation Methods

United Nations Statistics Division

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Why do we need to evaluate the census?

❑ The census is a huge operation comprised of many stages

❑ It is not perfect and errors can and do occur at all stages of the census operation

❑ Many countries have recognized the need to evaluate the overall quality of their census results and have employed various methods for evaluating census coverage as well as certain types of content error

Aims of census evaluation

- ❑ To provide users with a measure of the quality of census data to help them interpret the results

- ❑ To identify types and sources of error in order to assist with the planning of future censuses

- ❑ To serve as a basis for constructing the best estimate of census aggregates, such as total population, number of births, number of migrants

  - In some cases, as a basis for adjusting census results

Planning a Census Evaluation Program

❑ A census evaluation program should be developed as part of the overall census program and integrated with other census activities

❑ Census errors can happen at all phases of the census operation, including questionnaire design, mapping, enumeration, data capture, coding, editing, etc.

❑ The results of the evaluation should be made available to census data users

Scope and methods of evaluation

- ❑ The scope of the census evaluation programme should be decided during the census planning phase
- ❑ Scope might include, for example:
  - ■ Estimate coverage error at national, regional and/or provincial levels
  - ■ Analyze evidence of age misreporting
  - ■ Compare census data with independent data sources (surveys, registers) or previous censuses
- ❑ Methods of census evaluation should be determined according to resources and objectives

Institutional organization

- ❑ Establishing the census evaluation team
  - ■ Team should be trained in the evaluation techniques - demographic methods, use of other sources of data, etc.
  - ■ Team should consist of staff with experience in different census topics, including demography, education, housing, labor force, etc.
  - ■ Team should have background knowledge of historical events and changes in population structure in the country
  - ■ Team should collaborate with related institutions
- ❑ Equipment needed for census data evaluation, including hardware and software, should be assessed in the initial stage of planning
- ❑ Cost of evaluation should be included in overall census budget

Evaluation phase of census operation

- ❑ Preparations –census legislation, budget, administrative organization, mapping, pretests/pilot census, quality assurance programme, logistics, field organization, training, etc.
- ❑ Enumeration
- ❑ Data processing-capture, editing, imputation, validation
- ❑ **Evaluation of census results**
- ❑ Dissemination
- ❑ Analysis – policy oriented

What are census errors?

❑ Coverage errors:

- Errors in the count of persons or housing units resulting from cases having been "missed" or "counted erroneously"

❑ Content errors:

- Errors in the recorded characteristics of persons or housing units resulting from the interview operation (enumerators/respondents), coding, editing, etc.

Coverage errors - omissions

❑ Missing housing units, households, and/or persons during census enumeration

- ■ If the whole housing unit is missed, all households and persons living in the housing unit will also be missed

- ■ Major causes of omission are:
  - ❑ Failure to cover whole land area of a country in creating enumeration areas (EAs)
  - ❑ Ambiguous definitions of EAs, unclear boundaries of EAs, faulty maps or coverage error during the pre-census listing exercise
  - ❑ Mistakes made by enumerators in canvassing assigned areas

Coverage errors – omissions (2)

❑ In addition, omissions within EAs can occur if all or some of the members of the household were not present at the time of enumeration

❑ Proxy respondents (when data is collected from one member of the household on all other members of the household) can inadvertently or deliberately omit some members of a household

Coverage errors – erroneous inclusions

❑ This includes:

- Housing units, households and persons enumerated when they should have not been enumerated *(e.g. babies born after the census reference date)*

- Housing units, households and persons enumerated in the wrong place

- Households and persons living abroad enumerated in the country

Coverage errors - duplications

❑ Occur when persons, households or housing units are counted more than once

❑ Reasons for duplications include:

- Overlapping of enumerator's assignments owing to errors made during pre-census listing and delineation
- Failure by enumerators to clearly identify boundaries
  - o Individuals or households with more than one residence being counted in both places (e.g. students or migrant workers being counted in an institutional residence as well as their households of origin)

Coverage errors

Gross error

❑ This is the sum of duplications, erroneous inclusions and omissions

Net error

❑ This is the difference between over-counts and under-counts

■ Net census under-count exists when number of omissions ("missing" people) exceeds the number of duplicates and erroneous enumerations

■ Net census over-count is the opposite

➢ In practice, net under-counts are more common

Content errors

❑ Every phase of census data collection and processing has the potential for introducing errors into the census results

■ The interviewing operation in which enumerators and respondents can make errors

■ During many other operations such as coding and editing, personnel or procedures can cause errors that affect the census content

❑ Content errors add bias and non-sampling variance to the total mean square error of census statistics

Methods for the evaluation of census errors

Single Source of Data (rely only on the census being evaluated)

❑ Demographic analysis

  ■ *Consistency checks with expected pattern*

  ■ *Comparison with theoretical models*

❑ Interpenetration studies

Multiple Sources of Data

❑ Non-matching studies

  ■ *Demographic analysis using multiple census rounds*

  ■ *Comparison with administrative sources or existing surveys*

❑ Matching studies

  ■ *Post Enumeration Surveys*

  ■ *Record checks*

Source: U.S. Census Bureau, 1985. *Evaluating Censuses of Population and Housing*

Before using any of these evaluation methods…

- ❑ It is necessary that the evaluation team have a good understanding of the census process
  - ◼ Which population groups were included/excluded
  - ◼ Whether and how the data should be weighted
  - ◼ Any known problems with the enumeration and/or data entry and editing processes
  - ◼ If and how missing values have been edited
    - ❑ If there are no missing values on age and sex, the data has almost certainly been edited
    - ❑ Editing rules for logical imputation, hot-decking or any other method that was used should be well understood and their effects carefully considered

Understanding data editing and potential errors

Figure 2.4 Age distributions of unimputed and missing ages imputed from a hotdeck by population group, Census 2001
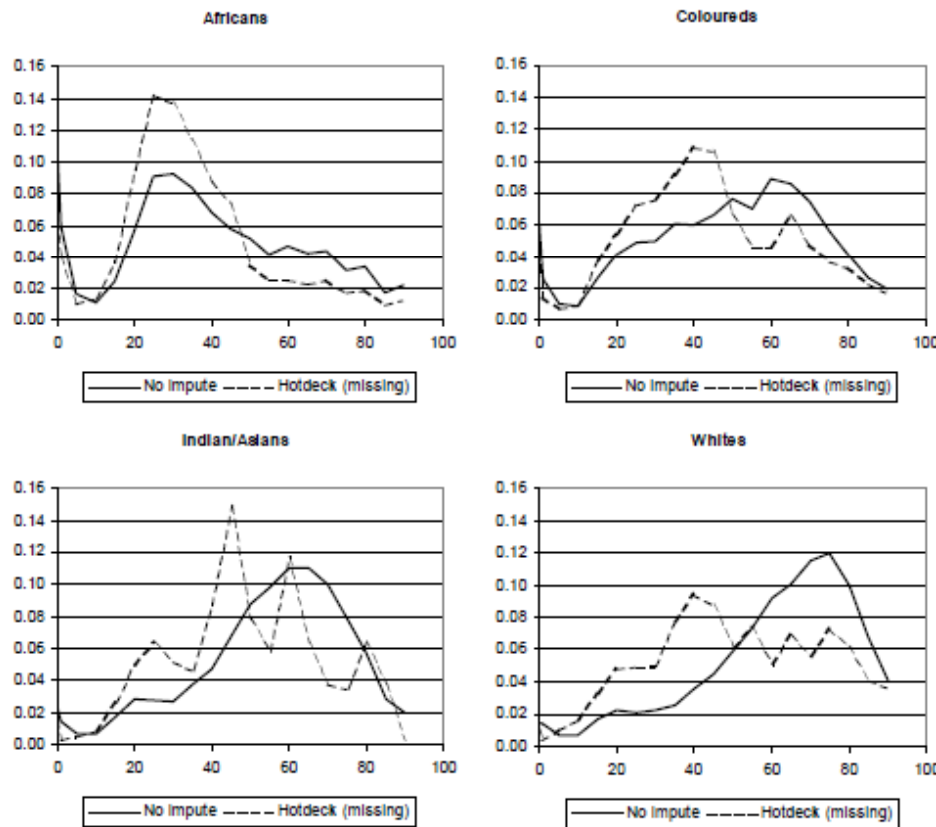
➢Data on deaths in the household – cases where age of deceased was hot-decked show different age pattern of mortality than cases that were not subject to imputation

Source: *Estimation of mortality using the 2001 South Africa census data,* Rob Dorrington, Tom Moultrie and Ian Timaeus, Centre for Actuarial Research, University of Cape Town

a Evaluation

Single source of data - demographic analysis

❑ Consistency checks with expected pattern

  ▪ Consistency of tabulated data and indicators with expected pattern

    Some examples;

    ☐ Age and sex distribution of population
    ☐ Average number of live births by age group of mother
    ☐ Proportion of married population by age group
    ☐ Literacy rate by rural/urban

❑ Comparison with theoretical expectations

    ☐ Many methods of analysis are based on stable population theory, which requires the assumption that fertility and mortality rates have not changed much in recent years – this will not hold in many developing countries

      ▪ violation of assumptions can cause discrepancies that may be difficult to distinguish from errors in the data

Demographic analysis – strengths and weaknesses

❑ Methods that depend on a single data source provide less insight into the magnitude and types of errors in the census in question because there is no empirical reference point against which to compare

- ■ Cannot measure relative contributions of coverage and content error to overall error
- ■ Can provide a general impression of quality of the census data

❑ The advantage is that the methods using such sources do not require additional data to be collected (or be already available)

❑ No need for sophisticated matching, although this is also a limitation

Single source of data – interpenetration studies

❑ Method involves drawing subsamples, selected in an identical manner, from the census frame

   ■ Each subsample should be capable of producing valid estimates of population parameters

   ■ Assignment of personnel (i.e. enumerators, coders, data entry staff, etc.) is done randomly

❑ Estimates of the same indicator are then generated from each subsample and compared

❑ The method helps to provide an appraisal of the quality of census data and procedures

Interpenetration studies – strengths and weaknesses

- ❑ Able to identify operational stages that contribute to census error, thus identifying procedural limitations in a census
- ❑ Cannot indicate relative magnitude of coverage vs. content error
- ❑ It is an expensive operation demanding many field staff, intensive training and close supervision
- ❑ Relatively complex in design and implementation

Multiple Sources of Data – Non-matching studies – Demographic analysis (1)

❑ When multiple sources of data are available, demographic analysis becomes a powerful tool for census evaluation

❑ Three main types of data sources can be compared with the census under evaluation

■ Previous censuses

■ Household surveys (e.g. the DHS, LFS)

■ Administrative data/official records (e.g. those derived from vital registration or school enrollment data), but without matching records

Multiple Sources of Data – Non-matching studies – Demographic analysis (2)

Previous Censuses

❑ Previous censuses can provide an expectation of what demographic or socioeconomic indicators should look like at the time of a subsequent census

- Expected population age-sex structure can be projected, incorporating assumptions about fertility, mortality and migration

- Some indicators, such as mean children ever born and proportion ever-married are expected to change monotonically in reasonable intervals with age

- A few socioeconomic characteristics, such as literacy, are not expected to change significantly over time once cohorts pass a certain age

Multiple Sources of Data – Non-matching studies – Demographic analysis (3)

Administrative data

❑ Certain characteristics, such as age, sex, total births, school enrollment, as measured by the census can be compared with same characteristics as measured by administrative data

❑ Without matching, this comparison can tell us only about aggregates – cannot tell us if the data collected on a particular individual or household are accurate

❑ Method depends on having adequately complete records for a well-defined segment of the population

Multiple Sources of Data – Non-matching studies – Demographic analysis (4)

Household surveys

❑ In theory, any nationally-representative survey should provide estimates of demographic or socioeconomic indicators that are comparable with the census

❑ Data from such surveys is expected to be of greater accuracy than the census because surveys are smaller operations and can be better controlled

❑ Surveys may be affected by sampling error

❑ Definitions of the indicators being compared should be the same across the survey and the census

❑ Surveys should ideally be independent of census, to avoid correlation between errors in the census and the survey

Multiple Sources of Data – Non-matching studies – Strengths and Weaknesses

Strengths

❑ Multiple censuses and fairly high-quality demographic surveys are increasingly available in many developing countries, making this method readily accessible

❑ No additional data is needed to be collected to perform the analysis

❑ This method is less expensive compared to matching studies

❑ In statistical offices with sufficient numbers of demographers there is no need for additional staff to do the technical analysis

Multiple Sources of Data – Non-matching studies – Strengths and Weaknesses

Weaknesses

❑ Non-matching methods provide less insight into the different contributions of component errors to total error in the census

❑ Allow for the evaluation of census results at aggregate rather than unit level, i.e. provides estimates of net census error only, not gross error

❑ Method is highly dependent on the quality of the other data sources and/or the assumptions used regarding inter-censal demographic rates

Multiple Sources of Data – Matching studies – Record checks (1)

❑ Census records are matched with a sample of records from official registration systems such as the vital registration system

❑ The relevant respondents to the census questionnaire are traced to the time of the census

❑ Sources include:

- Previous censuses
- Birth registration
- School enrollment
- National identification cards/registers
- Immigration registers
- Voter registration lists
- Health or social security records

Multiple Sources of Data – Matching studies – Record checks (2)

❑ Both coverage and content errors can be measured through the above comparisons

To evaluate coverage efficiently the following preconditions are essential:

❑ A large and clearly-defined segment of census population (if not the entire population) should be covered by the registration system

❑ The census and registration systems should be independent of one another

❑ There should be sufficient information in the records to be able to match them with census respondents accurately

Multiple Sources of Data – Matching studies – Record checks (3)

To evaluate content efficiently the following preconditions are essential:

- ❑ The register system should contain relevant items covered in the census such as age, sex, education, relationship, marital status etc.

- ❑ Definitions of variables should be identical between the census and the register

Some countries that have used record checks

Canada, Denmark, Italy, Norway

Record checks – strengths and weaknesses

- ❑ Can provide separate estimates of coverage and content error
- ❑ With the right data, more characteristics can be evaluated compared to what can be done with non-matching studies
- ❑ Calls for a high level of technical skill, including managerial capacity
- ❑ Matching is expensive
- ❑ In many countries, registration systems are not sufficiently complete for this method to be feasible

Multiple Sources of Data – Matching studies – Post-Enumeration Surveys (PES)

❑ A PES entails the complete re-enumeration of a representative sample of the population, which is then matched to the corresponding records – in the selected EAs- from the census enumeration

❑ PES can fulfill multiple objectives:

  ■ Assess the degree of coverage of the main enumeration
  ■ Assess implications of coverage error – better interpretation of census results
    ❑ Characteristics of those who have been missed or erroneously enumerated in the census
    ❑ Effects of coverage error on distribution of population by characteristics- region, sex, age, etc.
  ■ Assess how to improve census methodology

❑ In certain circumstances, the results of the PES may be used to adjust census results

Multiple Sources of Data – Matching studies – Post-Enumeration Surveys (PES)

- ❑ The PES should be operational independent from the census operation
  - ◼ Using sample frame independent of the census
    - ❑ Sampling units of PES are determined independently from the census units- necessary for application of Dual System Estimation
  - ◼ Field operation with different supervisors/enumerators
  - ◼ Different staff for data processing and analyses of the results
  - ◼ Avoid any operation or procedures of PES or the census that has potential to affect the other one

Multiple Sources of Data – Matching studies – Post-Enumeration Surveys (PES)

Advantages:

❑ The results of a PES can be used to independently evaluate census coverage and content error, including reliability of selected characteristics collected in a census

❑ Incorporates matching of individuals or units between the census and PES – this allows for a direct comparison of results

❑ Its results are generally more reliable than those of the census

Multiple Sources of Data – Matching studies – Post-Enumeration Surveys (PES)

Challenges:

❑ Requires highly skilled field and professional staff

❑ Matching is complex and costly

❑ The PES has to be conducted immediately after the census not to be affected by population movements, recall bias etc.

  ■ There might be a lack of adequate funds and staff to implement the PES exercise after the census

Scope of the workshop

❑ Focus on demographic analysis for census evaluation

- ■ Single census:
  - ❑ Assessment of major variables in the census to be evaluated (e.g. age, sex, children ever born)
  - ❑ Indirect estimation of demographic indicators
- ■ Multiple censuses:
  - ❑ Cohort analysis of various population characteristics
  - ❑ Relative coverage of two consecutive censuses
- ■ Census and other data sources:
  - ❑ Comparison of estimates derived from the census to those from household survey data – particularly the Demographic and Health Surveys (DHSs), Multiple Indicator Cluster Surveys (MICS), Labor force surveys (LFSs)
  - ❑ Comparison with administrative registers – vital registers, school enrollment, immigration records, etc.

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Resources

❑ United Nations, DESA/Statistics Division. 2008. *Principles and Recommendations for Population and Housing Censuses, Rev. 2*.

❑ United Nations, DESA/Statistics Division. 2010. *Post Enumeration Surveys: Operational Guidelines*.

❑ United Status Bureau of the Census. 1985. *Evaluating Censuses of Population and Housing*.

❑ IUSSP Tools for Demographic Estimation (in progress)

http://demographicestimation.iussp.org/