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Statistics Canada Quality Guidelines

Fourth Edition – October 2003

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Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

Preface

Statistics Canada places great importance on the management of data quality to ensure that its statistical outputs satisfy user needs. The variety of measures it uses to manage the various dimensions of quality is described in the Agency's Quality Assurance Framework (Statistics Canada, 2002c). Within this overall framework, the design and implementation of the programs that acquire statistical data, whether through sample surveys, censuses, or the use of administrative records, clearly occupy a pivotal role in the management of data quality. The adoption of sound survey methodology provides the basis for producing statistical data that satisfy the information requirements of users.

In the domain of survey methodology there is no overall professional code of practice, or set of standards, that defines good practice for all situations. Survey methodology is rather a collection of practices, backed by a combination of theory and empirical evaluation, among which practitioners have to make sensible choices in the context of particular applications. These choices must attempt to balance the often competing objectives of relevance, accuracy, timeliness, cost, and reporting burden.

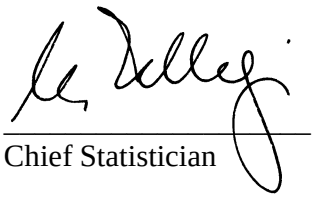
The present document consolidates a set of experiences and conclusions which, individually and in their particular contexts, have been judged to represent "good practice." They will not all apply equally to every data acquisition process. Their applicability and importance will have to be carefully considered in light of the particular requirements and constraints of individual programs. This document must therefore be used with considerable professional care and judgement.

While the guidelines provided in this document are no substitute for informed expertise and judgement on the part of survey design staff, the underlying concern for quality must pervade all our activities. All statistical program managers are responsible for ensuring that Statistics Canada's concern for quality is given appropriate weight in the design and implementation of statistical methods and procedures under their control.

The first edition of Quality Guidelines appeared in 1985. A subsequent edition with minor revisions was published in 1987. Significant developments in survey methodology since that time, for example in the integration of computer technology and electronic communications into data collection and processing, have led to changes in the flow of survey operations as well as to new approaches to the storage and dissemination of data. These advances in survey methodology motivated the issuing of a third version of the Guidelines in 1998. The present document has been significantly updated from the previous edition to reflect further advances in survey methodology over the past five years.

Thanks are due to the many Statistics Canada experts who have contributed to the preparation of these Guidelines over many years. The guidance of the Methods and Standards Committee and the comments of the Advisory Committee on Statistical Methods helped to make this a better document.

Ivan P. Fellegi



Chief Statistician

Table of contents

1. Introduction: Defining quality

This document brings together guidelines and checklists on many issues that need to be considered in the pursuit of quality objectives in the execution of statistical activities. Its focus is on how to assure quality through effective and appropriate design or redesign of a statistical project or program from inception through to data evaluation, dissemination and documentation. These guidelines draw on the collective knowledge and experience of many Statistics Canada employees. It is expected that Quality Guidelines will be useful to staff engaged in the planning and design of surveys and other statistical projects, as well as to those who evaluate and analyze the outputs of these projects.

Since the publication of the first edition of Quality Guidelines in 1985, there has been much discussion among national and international statistical agencies on the subject of *quality*, and this continues. While there is no standard definition of quality for official statistics, there is general acceptance among these agencies that quality embodies a broad notion of "fitness for use". Fitness for use encompasses not only the statistical quality concepts of variance and bias, but also other characteristics such as relevance and timeliness that determine how effectively statistical information can be used.

This broader definition of quality parallels similar views propounded by the *Total Quality Management* (TQM) movement. In part, to achieve and maintain a level of quality or fitness acceptable to users TQM advocates: knowing and understanding the clients' needs; involving employees in decision-making associated with meeting these needs; and continuously seeking to improve methods and processes. That attention to these three tenets will lead to quality improvement is as true for a statistical agency as it is for any other organization. Quality Guidelines reflects these three principles, as well as Statistics Canada's long-standing efforts to develop and disseminate reliable and objective statistical information that satisfies and anticipates critical needs.

Elements of quality

Statistics Canada defines quality or "fitness for use" of statistical information in terms of six constituent elements or dimensions: relevance, accuracy, timeliness, accessibility, interpretability, and coherence (Statistics Canada, 2002c).

The *relevance* of statistical information reflects the degree to which it meets the real needs of clients. It is concerned with whether the available information sheds light on the issues that are important to users. Assessing relevance is subjective and depends upon the varying needs of users. The Agency's challenge is to weigh and balance the conflicting needs of current and potential users to produce a program that goes as far as possible in satisfying the most important needs within given resource constraints.

The *accuracy* of statistical information is the degree to which the information correctly describes the phenomena it was designed to measure. It is usually characterized in terms of error in statistical estimates and is traditionally decomposed into bias (systematic error) and variance (random error) components. It may also be described in terms of the

major sources of error that potentially cause inaccuracy (e.g., coverage, sampling, nonresponse, response).

The *timeliness* of statistical information refers to the delay between the reference point (or the end of the reference period) to which the information pertains, and the date on which the information becomes available. It is typically involved in a trade-off against accuracy. The timeliness of information will influence its relevance.

The *accessibility* of statistical information refers to the ease with which it can be obtained from the Agency. This includes the ease with which the existence of information can be ascertained, as well as the suitability of the form or medium through which the information can be accessed. The cost of the information may also be an aspect of accessibility for some users.

The *interpretability* of statistical information reflects the availability of the supplementary information and metadata necessary to interpret and utilize it appropriately. This information normally includes the underlying concepts, variables and classifications used, the methodology of data collection and processing, and indications or measures of the accuracy of the statistical information.

The *coherence* of statistical information reflects the degree to which it can be successfully brought together with other statistical information within a broad analytic framework and over time. The use of standard concepts, classifications and target populations promotes coherence, as does the use of common methodology across surveys. Coherence does not necessarily imply full numerical consistency.

These dimensions of quality are overlapping and interrelated. There is no general model that brings them together to optimize or to prescribe a level of quality. Achieving an acceptable level of quality is the result of addressing, managing and balancing these elements of quality over time with careful attention to program objectives, costs, respondent burden and other factors that may affect information quality or user expectations. This balance is a critical aspect of the design of the Agency's surveys.

Survey

The term *survey* is used here generically to cover any activity that collects or acquires statistical data. Included are:

- a *census*, which attempts to collect data from all members of a population;
- a *sample survey*, in which data are collected from a (usually random) sample of population members;
- collection of data from *administrative records*, in which data are derived from records originally kept for non-statistical purposes;
- a *derived statistical activity*, in which data are estimated, modeled, or otherwise derived from existing statistical data sources.

The guidelines are written with censuses and sample surveys as the main focus. While many of the guidelines will apply also to the processing of administrative records also, an additional section (2.17) on the topic has been added in order to highlight considerations specific to that activity. The quality of derived statistical activities is, of course, largely determined by the quality of the component parts, and as such, derived statistical activities are not the direct focus of this document.

Design

The term *design* is used here to cover the delineation of all aspects of a survey from the establishment of a need for data to the production of final outputs (the microdata file, statistical series, and analysis).

The core of this document (Section 2) concentrates on quality issues as they relate to the design of individual surveys. It is, however, important to keep in mind that the context in which each individual survey is developed imposes constraints on its design. Each new survey, while aiming to satisfy some immediate information needs, is also contributing information to a base of statistical data that may be used for a range of purposes that go well beyond those identified at the time of the survey's design. It is therefore important to ensure that the output from each individual survey can, to the extent possible, be integrated with, and used in conjunction with, data on related topics derived from other surveys. This implies a need to consider and respect the statistical standards on content or subject-matter that have been put in place to achieve coherence and harmony of data within the national statistical system. These include statistical frameworks (such as the System of National Accounts), statistical classification systems (such as those for industry or geography), as well as other concepts and definitions that specify the statistical variables to be measured. The usefulness of new statistical data is enhanced to the extent that they can be utilized in conjunction with existing data.

The design process also takes place within an organizational context. These guidelines are written in the context of a centralized statistical agency within which the design of a survey is normally conducted through a multi-disciplinary project team. The principal players in the project team are a project manager and a group of specialists. The specialists generally include a subject-matter specialist, a methodologist, an informatics specialist, and an operations specialist. Sometimes one player will play more than one role, and sometimes several other roles must be added to the team; for example, specialists may be needed for geographic systems, public communications and dissemination.

Section 3 outlines the management context within which these Quality Guidelines are applied. Based on the Quality Assurance Framework, this description draws together policies, managerial processes, consultative mechanisms, and technical procedures that have a bearing on the management of quality at Statistics Canada. While Section 2 focuses mainly on the conduct of individual statistical activities, Section 3 provides a broader corporate perspective on quality assurance.

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2. Survey steps

This section is organized in subsections that correspond to the main activities of a typical survey. The subsections all follow the same structure, describing the *Scope and purpose*, *Principles,* and *Guidelines* related to each activity, as defined below. The first subsection addresses the stage at which objectives, uses and users (2.1) are identified. The subsections that follow cover other survey steps roughly in the chronological order in which they would typically take place. However, there are significant interdependencies between some steps such as, for example, between questionnaire design (2.5) and data collection and capture operations (2.7). For this reason cross-references between subsections are provided. As well, survey steps as discussed here do not always proceed strictly sequentially. Some activities can take place concurrently, for example, frame development (2.3), sampling plans (2.4), and questionnaire design (2.5). Other steps, such as data quality evaluation (2.12) and documentation (2.16), touch on most other activities and do not take place as discrete activities on their own. Finally, administrative data use (2.17) is discussed separately to address issues specific to this type of data source.

Scope and purpose

Under the heading of *Scope and purpose*, a description of the activity and an indication of its potential impact on quality are provided. Essentially, a definition and a context are established.

Principles

Principles are the broad, underlying policies, approaches and directions, that govern the design of the activity in question, with emphasis on those that relate to quality.

Guidelines

Guidelines are known good practices that have evolved in the design and implementation of statistical surveys. Not all of these Guidelines can be applied to every survey. They provide checklists to aid survey design. Judgement is still needed in deciding how to weigh the considerations that these Guidelines suggest.

On the other hand, Statistics Canada does have policies that have a bearing on many aspects of statistical activities in the Agency, and which may place requirements on the way particular activities are carried out. These are documented separately in the Statistics Canada Policy Manual. Wherever a policy has a bearing on a particular topic covered by these Guidelines, the existence and relevance of the policy is indicated.

2.1 Objectives, uses and users

Scope and purpose

Once a new statistical activity or the redesign of an ongoing activity is approved, the need for the information and the overall feasibility of the proposed project or activity has generally been well established. The planning process will also have included the definition of broad objectives, a targeted user population and the key questions or issues to which analysis will be directed. In order to translate this initial planning exercise into an actual collection vehicle, objectives and uses can now be stated more precisely to help ensure that the new or redesigned activity will meet specific user requirements.

Objectives are the purposes for which information is required, stated within the context of the program, research problem or hypotheses that gave rise to the need for information. *Uses* narrow down and specify more precisely the information needs, for example, by describing what decisions may be made based on the information collected and how such information will support these decisions. For periodic surveys, other uses may evolve over time. *Users* are the organizations, agencies, groups or individuals expected to use the information. Arriving at a consensus on specific objectives and uses facilitates making rational decisions with respect to survey design.

Principles

Specification of objectives and uses leads to the development of a detailed plan for the new activity, in consultation with users of the information and project participants. Users can help develop a description of the purposes of the activity. Project participants can identify the conceptual, methodological and operational issues that they must resolve and can suggest a reasonable schedule.

It is important to have a clear understanding and to formulate a concrete statement of the objectives in terms of hypotheses to be tested and specific data requirements, including the quality expected, budget constraints and expected delivery dates.

A statement of objectives will provide subsequent users who have different objectives with the means to assess the extent to which a product from a statistical activity may meet their own needs. It is also an important means of communicating to (potential) users what they can expect from the products of a statistical activity and the degree to which they will want to be careful when their use of the data extends beyond that which the activity set out to achieve.

Guidelines

- Focus analysis of user needs on finding the most cost-effective solutions for both the short and long term. Before embarking on the design of a new statistical activity (or redesigning an existing one), analyze currently available statistics in the area in terms of sources, frequency, quality, timeliness, etc. Deal with the

trade-off between adequacy of the available statistics to meet the requirements of clients and the cost and time required to undertake a new activity to produce statistics that do not already exist.

- Develop survey objectives in partnership with important users and stakeholders. Establish and maintain relationships with users of information in the private and public sectors and with the general public to enhance the relevance of the information produced and to improve the marketing of products and services. Among important users are representatives of potential markets, policy makers and agents who require the information for legislated use. Before major designs or redesigns, conduct extensive and user-focused consultation routinely so as to identify content options as well as to develop public support for the program when it reaches the data collection stage. Since even relevant and accurate statistics are not used if they are not trusted, take a very open approach when developing or revising programs so as to build confidence in the process and products of a statistical activity.

- In determining the extent to which a survey will meet user needs, seek a reasonable trade-off between these needs and the budget, response burden and privacy considerations. Although the Agency may have little discretion where a legal requirement is in place, in other cases it is worthwhile to formulate alternative methodological approaches, means and modes of data collection, frequencies, geographical detail, etc. with a view to arriving at an optimum solution.

- Review ongoing statistical activities at regular intervals. Statistical programs need to evolve, adapt and innovate so as to keep pace with the changing demands of the users they serve or demands of new users. The purpose of the activity or its statement of objectives needs to be reviewed periodically to enhance the relevance of the statistical product to user needs, as they involve or change. Sometimes the overhaul of existing surveys may be desirable to maintain the reliability of key statistical series, especially if sources of information have changed or the way in which they are made available is reengineered or rethought.

- Where explicit data quality targets exist, include them in the statement of survey objectives in terms of measurable aspects of quality. Targets can be set in terms of measures such as sampling error, coverage rates, response rates, and timeliness. With administrative data and derived statistical activities, the data quality will be directly related to the quality of input data sources.

- In determining the objectives and uses of a specific statistical activity, consider also the objectives and uses of derived statistical activities or statistical frameworks (e.g., the System of National Accounts).

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2.2 Concepts, variables and classifications

Scope and purpose

Concepts are the subjects of inquiry and analysis that are of interest to users. They refer to general characteristics or attributes of a statistical unit or of a population of like statistical units. *Variables* are the indicators used to measure the concepts. It is important that the definitions of the concepts and of the specific variables required for the measurement of the concepts be unambiguous and clearly specified in the context of the analytical purposes for which the data are to be collected. Since all categorical statistical data need to be classified for analysis, the *classification* criteria chosen to group data systematically need to be suitable for these analytical purposes.

Principles

In order to draw conclusions from a set of data, it is extremely important for users to have input to and knowledge of the concepts underlying the data, i.e., what the data purport to measure. Although the use of harmonized definitions of concepts, variables and classifications will assist users in comparing and integrating data, such definitions may need to be modified to meet the intended uses of the data. The definitions of the concepts, variables and classifications should be carefully documented, and any differences from standards or from those used to produce related data should be noted. This documentation is especially important for users who wish to apply the data for other than their intended use.

Sometimes, there is more than one way to measure a concept. The variables and classifications chosen to measure a concept will also need to take into account factors such as the ease of obtaining the information required, the respondent burden imposed, the collection method, the context in which the question(s) must be asked, the processing of the data (especially editing, imputation and weighting techniques), whether the information can be obtained from administrative records, and the costs associated with collection and processing. Thus, the measurement approach adopted may be more or less successful in providing the desired interpretation of the concept. A variable chosen at one point in time may become obsolete later if new factors come into play and may therefore need to be modified or changed.

Guidelines

- Specify concepts and variables clearly and relate them to their intended use. Wherever possible, make use of the standard definitions of concepts, variables, classifications, statistical units and populations established under the Statistics Canada Policy on Standards (Statistics Canada, 1998b). In choosing naming conventions, take into account the similarity or dissimilarity of existing standards and usage. Use titles from existing standards only for what is defined in the standards.

- To maximize flexibility of use, code microdata and maintain files at the lowest possible level of the appropriate classification. Aggregation at a higher level may be required for particular analytical purposes or to satisfy confidentiality or data reliability constraints. Wherever possible, use a common collapsing strategy for these aggregations and define them in terms of the classes or higher-level aggregations of the standard. Document differences between the standard and adopted levels of classifications/aggregations used. Use classifications that reflect both the most detailed and the collapsed levels. Make clear to users how these fit into higher-level (i.e., less detailed) classifications.

- Use standard definitions to make it possible to compare data collected from different sources and to integrate data across sources (Statistics Canada, 1998b). Statistics Canada has standard classifications of industries, products, occupations and geography (Statistics Canada, 2001b, 2001c, 2002b, 2003c) as well as of a large number of other variables used for social and economic statistics (Statistics Canada, 2000c).

- In addition to Statistics Canada's standard classifications, there are international standard classifications produced by the United Nations Statistical Office, the International Labour Office, Eurostat, and other international and regional agencies. The Standards Division has produced official concordances to a number of international standard classifications. When there is a requirement to provide data to international agencies, use official concordances when they are available.

- Use standard units of observation to facilitate the comparison of data. Classifications are usually designed with particular units of observation in mind. For example, the North American Industry Classification is designed primarily for classifying establishments.

- Be aware of derived statistical activities or statistical frameworks (e.g., the System of National Accounts) whose definitions of concepts and variables may have a significant effect on specific data collection activities (Statistics Canada, 1989).

- In the absence of an official standard, examine the concepts, variables and classifications being used by related statistical programs and consult with the Standards Division when necessary.

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2.3 Coverage and frames

Scope and purpose

The *target population* is the set of elements about which information is wanted and estimates are required. Practical considerations may dictate that some units be deliberately excluded (e.g., institutionalized individuals, the homeless, or those that are not be possible to access without incurring excessive cost). This gives arise to the concept of the *survey population*, the set of units that the practical constraints force us to narrow down to, by excluding some units that are hard or expensive to access to. Differences between the target population and the survey population are the result of deliberate restrictions to coverage. If the two differ, valid statistical inference under probability sampling can be made about the survey population, not about the target population itself.

A *frame* is any list, material or device that delimits, identifies, and allows access to the elements of the survey population. Frames are generally of two types: area frames and list frames. Area frames are usually made up of a hierarchy of geographical units, that is, the frame units at one level can be subdivided to form the units at the next level. All the elements included in the frame constitute the *frame population*. The discrepancies between the survey population and the frame population are referred to as *coverage errors*.

Principles

The survey frame should conform to the survey population and contain minimal undercoverage and overcoverage. Frame information must be kept up-to-date. Coverage errors occur due to omissions, erroneous inclusions, duplications and/or misclassifications of the units in the survey frame.

Characteristics of the frame units (e.g., identification, contact, classification, address, size, maps in case of geographical units) should be of high quality because of their use in stratification, sample selection, collection, follow-up, data processing, imputation, estimation, record linkage, quality assessment and analysis. Frame imperfections such as coverage errors and out-of-date characteristics are likely to bias or diminish the reliability of the survey estimates and to increase data collection costs.

Guidelines

- Test possible frames at the planning stage of a survey for their suitability and quality.

- When several frames exist, some of which are incomplete but less expensive to use and others more complete but prohibitively expensive, consider the use of multiple frames (Hartley, 1962; Bankier, 1986; Sirken and Casady, 1988; Kott and Vogel, 1995). Random Digit Dialling (RDD) may also be used for some telephone surveys, by itself or in combination with other area or list frames.

- At Statistics Canada, for business and institutional surveys, the Business Register is the usual frame. For agricultural surveys, the Farm Register is the usual frame. For household surveys, the Address Register, the Labour Force Survey frame (which is an area frame), telephone files and the Census of Population geographic units are options to consider.

- Where possible, use the same frame for surveys with the same target population, to avoid inconsistencies, to facilitate combining estimates from the surveys and to reduce costs of frame maintenance and evaluation.

- Retain and store information about sampling, rotation and data collection so that coordination between surveys can be achieved and respondent relations and response burden can be better managed. For example, record how often each unit is selected by each survey that is using the frame.

- To improve and/or maintain the level of quality of the frame, incorporate procedures to eliminate duplication and to update for births, deaths, out-of-scope units and changes in characteristics.

- Monitor the frame quality by periodically assessing its coverage and the quality of the information on the characteristics of the units. Many techniques exist for this purpose:
  - matching the frame or a sample of the frame with comparable alternative sources, often provided by administrative records, for the survey population or subsets of it;
  - analyzing survey returns for duplicates, deaths, out-of-scope units, and changes in characteristics;
  - using specific questions on the questionnaire to aid in monitoring coverage and classification information; verifying with local authorities (e.g., regional offices, field survey staff, the survey units themselves);
  - verifying the frame or subsets of it in the field (which could include verification of out-of-scope units);
  - comparing the frame with a sample of units from a corresponding area frame;
  - updating the frame to determine changes to it;
  - checking the consistency of counts with other sources or with data from specially designed replicates;
  - using evaluative information obtained from other surveys with the same frame (Lessler and Kalsbeek, 1992).

- Monitor the frame between the time of sample selection and the survey reference period.

- Incorporate frame updates in the timeliest manner possible.

- Minimize frame errors through effective training of staff, an emphasis on the

importance of coverage, and the implementation of quality assurance procedures of frame-related activities.

- For area frames, implement map checks to ensure clear and non-overlapping delineation of the geographic areas used in the sampling design (e.g., through field checks or the use of other map sources). When appropriate, use the Generalized Area Delineation System (GArDS) for creating the geographic frame units.

- For statistical activities from administrative sources or for derived statistical activities, where coverage changes may be outside the control of the immediate manager, determine and monitor coverage, and negotiate required changes with the source manager.

- Make adjustments to the data or use supplementary data from other sources to offset coverage error of the frame.

- Include descriptions of the target and survey populations, any differences between the target population and the survey population, as well as the description of the frame and its coverage errors in the survey documentation.

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2.4 Sampling

Scope and purpose

Sampling is the selection of a set of units from a survey population. This set of units is referred to as the *sample*. The choice of sampling method has a direct impact on data quality. It is influenced by many factors, including the desired level of precision and detail of the information to be produced, the availability of appropriate sampling frames, the availability of suitable auxiliary variables for stratification and sample selection, the estimation methods that will be used and the available budgets.

Principles

Probability sampling is used to select a sample from the survey population. The intention is to gather useful information from the sampled units to allow inferences about the survey population. Probability sampling implies a probabilistic selection of units from the frame in such a way that all survey population units have known and positive *inclusion probabilities*. Sample size is determined by the required precision and available budget for observing the selected units. The probability distribution that governs the sample selection, along with the stages and units of sampling, the stratification, and so on, are collectively called the *sampling design* or *sample design*. A combination of sampling design and estimation method (see Section 2.10) is chosen so that the resulting estimates attain the best possible precision under the given budget, or so as to incur the lowest possible cost for a fixed precision. Information collected for sampled units may, where appropriate, be supplemented at the estimation stage, with *auxiliary information* from other sources than the survey itself, (such as administrative records and census projections) to improve the precision of the estimates. The choice of sampling design will take into account the availability of such auxiliary information. These concepts are discussed in Särndal, Swensson and Wretman (1992) and Tillé (2001).

Guidelines

- *Stratification* consists of dividing the population into subsets (called *strata*) within each of which an independent sample is selected. The choice of strata is determined based on the objective of the survey, the distribution characteristics of the variable of interest, and the desired precision of the estimates. Most surveys are used to produce estimates for various *domains* of interest (e.g., provinces). If feasible, take this into account in the design by stratifying appropriately (e.g., by province). Otherwise, it will be necessary to consider special methods at the estimation stage to produce estimates for these domains (see Section 2.10). To achieve statistical efficiency, create strata in such a way that each stratum contains units that are as homogeneous as possible with respect to the information requested in the survey. For longitudinal surveys, choose stratification variables that correspond to characteristics that are stable through time.

- For highly skewed populations, create a stratum of large units to be included in the survey with certainty. These large units would normally account for a significant part of the estimates of the population totals.

- Sometimes the information needed to stratify the population is not available on the frame. In such cases, a *two-phase sampling* scheme may be used, whereby a large sample is selected in the first phase to obtain the required stratification information. This first sample is then stratified and in the second phase, a subsample is selected from each stratum within the first sample. Consider the cost of sampling at each phase, the availability of the information required at each phase, and the gain in precision obtained by stratifying the first-phase sample.

- In practice, particularly in case of area frames, it is sometimes difficult or not cost-effective to select or inconvenient to directly select and contact the units that will report the requested information. In such cases, a *two-stage sampling* scheme may be used by first selecting *clusters* (called *primary sampling units*) of reporting units, and then subsampling within each of the selected primary sampling units to obtain a sample of the reporting units. Budgetary or other constraints may necessitate more than two stages. Determine how many stages of sampling are needed and which sampling units are appropriate at each stage. For each possible type of unit, consider the availability of a suitable frame of such units at each stage or the possibility of creating such a frame for the survey, ease of contact and of data collection/measurement, the quality of the data provided by the unit, and the cost of collection.

- When determining sample size, take into account the required levels of precision needed for the survey estimates, the type of design and estimator to be used, the availability of auxiliary information, budgetary constraints, as well as both sampling factors (e.g., clustering, stratification) and nonsampling factors (e.g., nonresponse, presence of out-of-scope units, attrition in longitudinal surveys). For periodic surveys, take into account expected births and deaths of units within the changing survey population.

- It is important to remember that most surveys produce estimates for many different variables, and optimizing the sample for one particular variable may have detrimental effects on other important variables. Handle this problem by first identifying the most important variables and then using this subset of variables to determine the sampling strategy to be adopted, which often requires a compromise between optimum strategies for the variables in the subset.

- In determining sample allocation and size for stratified samples, account for expected rates of misclassification of units and other deficiencies on the frame. If not properly considered at the sampling stage, survey estimates will not be as precise as planned. Address this problem at the estimation stage (see Section 2.10).

- Conduct studies to evaluate alternative sampling methods, stratification options and allocation possibilities. The usefulness of these studies depends on the availability and vintage of data used to conduct the studies, whether from previous censuses, surveys or administrative data and their relation to the variables of importance to the survey.

- At the implementation stage, compare the size and characteristics of the actual sample to what was expected. Compare the precision of the estimates to the planned objectives.

- For periodic surveys that use designs in which the sample size grows as the population increases, it is often appropriate to develop a method to keep the sample size and therefore collection costs, stable. The *precision* of survey estimates is usually influenced more by the total sample size than by the *sampling fraction* (ratio of the sample size to the population size).

- For periodic surveys, make the design as flexible as possible to deal with future changes, such as increases or decreases in sample size, restratification, resampling and updating of selection probabilities. If estimates are required for specified domains of interest (e.g., subprovincial estimates), form the strata by combining small stable units related to the identified domains (e.g., small geographical areas), if possible. Future changes in definitions of the strata would then be easier to accommodate.

- For periodic surveys, if efficient estimates of change are required or if response burden is a concern, use a *rotation* sampling scheme that replaces part of the sample in each period. The choice of the rotation rate will be a compromise between the precision required for the estimates of change, and the response burden on the reporting units. Lowering the rotation rate will increase the precision of the estimates of change, but may lower the response rate over time. A low rotation rate has the additional benefit of reducing costs if the first contact is substantially more expensive than subsequent contacts.

- For periodic surveys, develop procedures to monitor the quality of the sample design over time. Set up an update strategy for selective redesign of strata that have suffered serious deterioration.

- For longitudinal panel surveys, determine the length of the panel (its duration of time in the sample) by balancing the need for duration data versus attrition and conditioning effects. Use a design with overlapping panels (i.e., with overlapping time span) when there is a need to produce cross-sectional estimates along with the longitudinal ones.

- Use generalized sample selection software instead of tailor-made systems. One such system is the Generalized Sampling System (GSAM) developed by Statistics Canada. GSAM is especially useful for managing sample selection and rotation

for periodic surveys. Another option is the software MICROSTRATE developed by Eurostat to control sample overlap. By using generalized systems, one can expect fewer programming errors, as well as some reduction in development costs and time.

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2.5 Questionnaire design

Scope and purpose

A *questionnaire* is a set of questions designed to collect information from a respondent. A questionnaire may be interviewer-administered or respondent-completed, using paper-and-pencil methods of data collection, telephone methods or computer-assisted modes of completion or Internet data collection. Questionnaires play a central role in the data collection process. They have a major impact on respondent behavior, interviewer performance, collection cost and respondent relations and therefore on data quality.

Principles

The design of questionnaires takes into account the statistical requirements of data users, administrative requirements of the survey organization, and the requirements for data processing, as well as the nature and characteristics of the respondent population. Good questionnaires impose low response burden and remain both respondent and interviewer-friendly. They ask relevant questions and permit data to be collected efficiently and with a minimum number of errors, while facilitating the coding and capture of data and minimizing the amount of editing and imputation that is required.

Questionnaires in ongoing surveys should be evaluated periodically. All new and modified questionnaires developed at Statistics Canada must be tested in both English and French before implementation, as required by the Agency's Policy on the Review and Testing of Questionnaires (Statistics Canada, 2002a; see Appendix 1).

Guidelines

- Use words and concepts in questionnaires that have the same meanings for both respondents and questionnaire designers, and, in the case of businesses, choose questions, time reference periods, and response categories that are compatible with the establishment's record-keeping practices. To the extent possible, harmonize concepts and wording with those already in use. When appropriate, reuse questions from other surveys.

- Choose question design and wording that encourage respondents to complete the questionnaire as accurately as possible. To this end, the questionnaire must focus on the topic of the survey, be as brief as possible, flow smoothly from one question to the next, facilitate respondents' recall and direct them to the appropriate information source.

- In the introduction to the questionnaire, provide the title or subject of the survey, identify the sponsor, explain the purpose of the survey, and request the respondent's cooperation. Also indicate the authority under which the survey is taken, and what confidentiality protection measures, record linkage plans and any data sharing arrangements that are in place (Statistics Canada, 1998a). The

opening questions should be applicable to all respondents, be easy and interesting to complete, and establish that the respondent is a member of the survey population.

- Ensure that the value of providing information is made very clear to respondents, and explain why it is important to complete the questionnaire and how the survey data will be used.

- Design self-completed questionnaires to be attractive and easy to complete. To this end, give a positive first impression in the cover letter and front cover, and make the questionnaire appear professional and businesslike. If it is to be interviewer-administered, make the questionnaire interviewer-friendly.

- To minimize the possibility of reporting errors, ensure that the instructions to respondents and/or interviewers are short, clear, and easy to find. Provide definitions at the beginning of the questionnaire or in specific questions, as required. Ensure that time reference periods and units of response are clear to the respondent, use boldface print to emphasize important items, specify "include" or "exclude" in the questions themselves (not in separate instructions), and ensure that response categories are mutually exclusive and exhaustive.

- With respect to the questionnaire layout, provide titles or headings for each section of the questionnaire, and include instructions and answer spaces that facilitate accurate answering of the questions. Use color, shading, illustrations and symbols to attract attention and guide respondents or interviewers to the parts of the questionnaire that are to be read and to indicate where answers are to be placed. At the end of the questionnaire, provide space for additional comments by respondents and include an expression of appreciation to the respondent.

- Choose among a wide range of methods to test and evaluate the questionnaire. The suitability and intensity of their use depend on various factors and circumstances. These include the type and size of the survey, the survey's content, utilization of previous survey questions or standard questions, whether it is an ongoing collection or not, the method of data collection, the project schedule, the budget, and the availability of resources (Statistics Canada, 2002a; see Appendix 1).

- Consider two or more phases of questionnaire testing. This involves testing the questionnaire at an early stage of its development, making revisions to the questionnaire based on the findings, and then testing the revised questionnaire. This process may be repeated through two, three or even more phases of testing. Different methods of testing the questionnaire may be used during each phase of testing.

- Use qualitative testing to provide insight into how respondents react to a questionnaire. Methods include focus groups and in-depth interviews, cognitive

methods such as think-aloud interviews and paraphrasing, and behavior coding. Focus groups and one-on-one, in-depth interviews are used to test and evaluate question wording, sequencing and format. Cognitive methods are used to examine respondents' thought processes as they answer the survey questions and to ascertain whether or not they understand the questions and are able to provide accurate responses. Behavior coding provides a systematic and objective means of examining the effectiveness of the questionnaire by analyzing the interviewer-respondent interaction. Qualitative testing may also be used to help determine questionnaire content through the evaluation and exploration of key concepts.

- Conduct informal testing (pretesting) of the questionnaire to help identify poor question wording or ordering, errors in questionnaire layout or instructions, and problems caused by the respondent's inability or unwillingness to answer the questions. Use informal testing to suggest additional response categories that can be pre-coded on the questionnaire, and to provide a preliminary indication of the interview length and potential nonresponse problems.

- Hold debriefing sessions with interviewers after testing the questionnaire. Let interviewers discuss their experiences in interviewing respondents and how the questionnaire performed. They can identify potential sources of response and nonresponse errors as well as areas where the questionnaire can be improved.

- Use split sample testing when there is a need to determine the "best" of two or more alternative versions of the questionnaire. This involves an experimental design that is incorporated into the data collection process to investigate issues such as question wording, question sequencing, and data collection procedures.

- Conduct pilot testing after a thorough questionnaire test to observe how all the survey operations, including the administration of the questionnaire, work together in practice. The pilot test duplicates the final survey design on a small scale from beginning to end, including data processing and analysis. It provides an opportunity to fine-tune the questionnaire before its use in the main survey.

- Verify French and English versions of the questionnaire for consistency.

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2.6 Response and nonresponse

Scope and purpose

Despite the best efforts of survey managers and operations staff to maximize response, some nonresponse will occur. For a unit to be classified as responding, the degree of *item response* or *partial response* (where an accurate response is obtained for only some of the data items required from a respondent) must meet a minimum threshold level below which the response would be rejected and considered a *unit nonresponse*. In such an instance, the sampled person, household, business, institution, farm or other unit is classified as not having responded at all.

Nonresponse has two effects on data: first, it introduces bias in estimates when nonrespondents differ from respondents in the characteristics measured; and second, it contributes to an increase in the sampling variance of estimates because the effective sample size is reduced from that originally sought.

Principles

The degree to which efforts are made to get a response from a nonrespondent is based on budget and time constraints, its impact on the overall quality and the risk of nonresponse bias. If nonresponse persists, adjustments are subsequently made to the data to compensate for nonresponse. Decisions on the appropriate degree of research to be undertaken to develop nonresponse adjustment techniques are likewise influenced by issues of budget, time, use of data and risk of bias. Nonresponse is monitored for feedback to survey staff for immediate and future action and is reported to users of the survey data. An effective respondent relations program and a well-designed questionnaire are critical elements in maximizing response (see Section 2.5).

Guidelines

- A good *response rate* is obtained in part by ensuring an appropriate level of quality during all of the survey planning and implementation steps. Take an integrated approach so that nonresponse management techniques are not duplicated. To attain a desired response rate, keep in mind the following factors:
  - the quality of the survey frame (in terms of population coverage and facility of establishing contact with the respondent);
  - survey population;
  - method of data collection (for example, by mail, personal interview, telephone interview, computer assisted interview);
  - sampling method;
  - time of year and length of collection period;
  - response burden imposed (length of interview, difficulty of subject matter, timing and periodicity of the survey);
  - nature of subject matter (sensitivity of subjects);
  - length and complexity of the questionnaire;

- the effectiveness and scope of the follow-up methodology;
- expected difficulties in tracing respondents who have moved;
- prior experience with same type of survey;
- prior experience and demonstrated ability of collection staff;
- workload of collection staff;
- established relationships with respondents;
- the communications strategy;
- the total budget;
- allocation of the budget to the various operations;
- language of the questionnaire;
- the cultural backgrounds of respondents;
- the importance of the survey to users and respondents;
- factors related to interviewers themselves such as training, experience, interpersonal skills, rapport building and turnover; and
- the use and effectiveness of respondent incentives.

■ Use a pretest as well as previous occasions of the same or similar surveys, among other means, to establish an expected response rate.

■ When operational constraints permit, follow up the nonrespondents (all or a sub-sample of them). Following up nonrespondents increases the response rate and can help ascertain whether respondents and nonrespondents are similar in the characteristics measured. Such follow-up is particularly important in the case of longitudinal surveys where the investment is clearly more long-term and the sample is subject to accumulating attrition (and possibly bias) due to nonresponse at each survey occasion. In this case, tracing activities are of particular importance.

■ For longitudinal surveys, facilitate high quality tracing. Obtain extra contact information for sampled units at each survey occasion. Provide a "Change of address" card and ask the sampled unit to notify the Agency if a move happens in between survey cycles. This will help obtain up-to-date contact information. In addition, administrative data, city and telephone directories, and many other sources including local knowledge are valuable to the tracing staff.

■ Prioritize follow-up activities. For example, in business surveys, follow-up large or influential units first, possibly at the risk of missing smaller units (see Section 2.8). Likewise, give a higher priority to nonresponding units in domains with high potential for nonresponse bias. A score function can be used to prioritize the follow-up.

■ Record and monitor the reasons for nonresponse (e.g., refusal, non-contact, temporarily absent, technical problem). The degree of nonresponse bias may differ depending on the reason. Monitor nonresponse trends by reason.

■ Since differences between respondents and nonrespondents can cause biases in

the estimates, try to determine if such differences exist. Although difficult to determine, this can be done in part by linking to external data sources (for example, administrative data files), and in part by examining the responses of the nonrespondents who were converted during a follow-up. Often it is easier to compare known characteristics of respondents and nonrespondents to see the extent of differences. In the case of longitudinal (or rotating) surveys, known characteristics of respondents at one wave of the survey can be analyzed to compare characteristics of respondents and nonrespondents at a subsequent wave. Information so gained may influence methods of compensation for nonresponse.

- Two main approaches to dealing with missing data are (Kalton and Kasprzyk, 1986): by means of sampling weight adjustment (see Section 2.10), or through the use of imputation (see Section 2.9). When appropriate, attempt to evaluate the extent to which the procedures correct for the potential bias. Take nonresponse into account when producing estimates and their associated variance estimates.

- Report response and nonresponse rates (Statistics Canada, 2000d; see Appendix 2). At Statistics Canada, standards and guidelines for reporting nonresponse have been established (Statistics Canada, 2001d). Inform users regularly of the nonresponse rate when providing estimates. Record unweighted and weighted nonresponse rates at the estimation stage on the Integrated Metadatabase (IMDB). Attempt to conform to the nonresponse reporting standard in order to facilitate comparability between surveys. The guidelines state that all units are to be classified as responding or nonresponding. Indicate clearly when there are units that responded partially, and how these units were classified.

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2.7 Data collection and capture operations

Scope and purpose

Data collection is any process whose purpose is to acquire or assist in the acquisition of data. Collection is achieved by requesting and obtaining pertinent data from individuals or organizations via an appropriate vehicle (see Section 2.5). If no information is obtained initially, or if the data are deemed unsuitable as identified by preliminary editing, follow-up contacts may be initiated as part of data collection (see Section 2.8).

Data Capture refers to any process that converts the information provided by a respondent into electronic format suitable for use by subsequent processes. Sometimes data are captured as part of the collection process in surveys using instruments such as CAPI, CATI and EDR. At other times, a separate operation needs to be set up for capturing data by manual key entry or automated means (e.g., ICR). Often this conversion of data involves either manual or automated *coding*, and sometimes it includes transmitting the data to another location.

The impact of data collection and capture operations on data quality is both direct and critical, as these data are the primary inputs of a survey-taking agency. The quality of these operations thus has a very high impact on the quality of the final product.

Principles

Respondents, or data suppliers, especially individuals and organizations who complete questionnaires, invariably without payment, are a survey-taking organization’s most valuable resource. To ensure continuing cooperation, it is essential to minimize the burden on respondents. Gaps or inconsistencies in the data are best corrected by consulting respondents themselves during data collection or very soon afterwards. Given data collection and capture operations' high impact on data quality, use of appropriate quality and performance measurement tools to manage these processes and provide objective measures to supervisors and clients is highly recommended. Throughout the process, appropriate steps must be taken to preserve the confidentiality of the information collected (see Section 2.13).

Guidelines

- Interviewers and data capture operators are critical to the success of most data collection and capture operations. Ensure that they have appropriate training and tools (e.g., training manuals, see Burgess and Brierley, 1995).

- Exploit available technology to improve the efficiency and quality of data collection and capture processes. Advances in communications and computing technology offer opportunities to greatly reduce the costs and risks associated with these processes. For example, computer-assisted survey interviewing (e.g., CAPI and CATI) and electronic data reporting (EDR) via the Internet, automated

data entry (using ICR) and automated coding by text recognition (ACTR) are approaches that take advantages of available technologies.

- Carefully control paper questionnaire delivery operations in mail surveys to ensure that each unit that has been selected to be in the survey receives the appropriate questionnaire. Once the questionnaire is returned, verify the accuracy of the coverage information and the quality of the data provided. Follow-up interviews may be needed in some cases. When no questionnaire is received, follow-up activities are necessary to establish the status of the unit (e.g., occupied or unoccupied; in business or out of business) and to obtain the missing information. Through all these steps, put in place a system to report on the completion status of each unit.

- Establish appropriate sample control procedures for all data collection operations. Such procedures track the status of sampled units from the beginning through the completion of data collection so that data collection managers and interviewers can assess progress at any point in time. Sample control procedures and feedback from them are also used to ensure that every sampled unit is processed through all data collection and capture steps, with a final status being recorded.

- Institute effective control systems to ensure the security of data capture, transmission and handling. Prevent loss of information and the resulting loss in quality due to system failures or human errors.

- When collecting data, ensure that the respondent or the appropriate person within the responding household or organization is contacted at the appropriate time so that the information is readily available. Allow the respondent to provide the data in a method and format that is convenient to them or their organization. This will help increase response rates and improve the quality of the information obtained from the respondents.

- In designing data collection processes, especially editing and coding, make sure that the procedures are applied to all units of study as consistently and in as error-free a manner as possible. Automation is desirable. Enable the staff or systems to refer difficult cases to a small number of knowledgeable experts. Centralize the processing in order to reduce costs and make it simpler to take advantage of available expert knowledge. Given that there can be unexpected results in the collected information, use processes that can be adapted to make appropriate changes if found necessary from the point of view of efficiency.

- Monitor the frequency of edit rejects, the number and type of corrections applied by stratum, collection mode, processing type, data item and language of the collection. This will help in evaluating the quality of the data and the efficiency of the editing function.

- Expenditure, performance and quality measures gathered during the data collection operation enable the survey manager to make decisions regarding the need for modification or redesign of the process. Track actual costs of postage, telephone calls, collection vehicle production, computing, and person-day consumption. Important quality measures include response rates, processing error rates, follow-up rates and counts of nonresponse by reason. When these measures are available at all levels at which estimates are produced and at various stages of the process, they can serve both as performance measures and measures of data quality (see Section 2.6).

- Manual data capture from paper questionnaires or scanned images is subject to keying errors. Incorporate on-line edits for error conditions that the data capture operator can correct (i.e., edits that will identify keying errors). Record these cases for later review and analysis.

- Implement verification procedures to assess how well operators are meeting the pre-established levels of keying error rates.

- Use statistical quality control methods to assess and improve the quality of collection and capture operations. Collect and analyze quality control measures and results in a manner that would help identify the major root causes of error. Provide feedback reports to managers, staff, subject-matter specialists and methodologists. These reports should contain information on frequencies and sources of error (see Mudryk et al, 1994, 1996 and 2002; Mudryk and Xiao, 1996). Various software tools are available to help in this regard. These include the Quality Control Data Analysis System (QCDAS) and NWA Quality Analyst (see Mudryk, Bougie and Xie, 2002).

- Use measures of quality and productivity to provide feedback at the interviewer or operator level, as well as to identify error-causing elements in the design of the collection vehicle or its processing procedures.

- Use subsequent survey processes to gather useful information regarding quality that can serve as signals that collection and capture procedures and tools may require changes for future survey cycles. For example, the editing or data analysis stages (see Sections 2.8 and 2.15) may suggest the possibility of response bias or other collection-related problems.

- Conduct a post mortem evaluation of all data collection and capture operations, and document the results for future use.

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2.8 Editing

Scope and purpose

Data *editing* is the application of checks to detect missing, invalid or inconsistent entries or to point to data records that are potentially in error. Some of these checks involve logical relationships that follow directly from the concepts and definitions. Others are more empirical in nature or are obtained as a result of the application of statistical tests or procedures (e.g., outlier analysis techniques). The checks may be based on data from previous collections of the same survey or from other sources.

Editing encompasses a wide variety of activities, ranging from interviewer field checks, computer-generated warnings at the time of data collection or capture, through identification of units for follow-up, all the way to complex relationship verifications, error localization for the purposes of imputation, and data validation. The last two topics will be addressed in Sections 2.9 and 2.12.

Principles

The goals of editing are threefold (Granquist, 1984): to provide the basis for future improvement of the survey vehicle, to provide information about the quality of the survey data, and to tidy up the data. There is good reason to believe that a disproportionate amount of resources is concentrated on the third objective of "cleaning up the data." As a result, learning from the editing process often plays an undeserved, secondary role.

It is recognized that *fatal errors* (e.g., invalid or inconsistent entries) should be removed from the data sets in order to maintain the Agency's credibility and to facilitate further automated data processing and analysis. However, a caution against the overuse of *query edits* (those pointing to questionable records that may potentially be in error) must be heeded. Data editing is most likely the single most expensive activity of a sample survey or census cycle. It is estimated to account for at least one-quarter of the total survey budget on average, reaching as high as 40% in the case of business surveys (Gagnon, Gough and Yeo, 1994). When the impact of such painstaking, often manual, editing on the final estimates is negligible it is called *over-editing*. Not only is the practice of over-editing costly in terms of finances, timeliness and increased response burden, but it can also lead to severe biases resulting from fitting data to implicit models imposed by the edits.

Guidelines

- Ensure that all edits are internally consistent (i.e., not self-contradictory).

- Reapply edits to units to which corrections were made to ensure that no further errors were introduced directly or indirectly by the correction process.

- Editing is well suited for identifying fatal errors (Granquist and Kovar, 1997) - since the process for this process can be easily automated. Perform this activity as quickly and as expediently as possible. While some manual intervention may be necessary, generalized, reusable software is particularly useful for this purpose. Banff – the SAS release of the Generalized Edit and Imputation System (Statistics Canada, 2000a) – and CANCEIS – the Canadian Census Edit and Imputation System (Bankier et al, 1999) - are examples of such software.

- *Hit rates* of edits, which is the proportion of warning or query edits that point to true errors, have been shown to be poor, often as low as 20-30% (Linacre and Trewin, 1989). Furthermore, the impact of errors has been shown to be highly differential, particularly in surveys that collect numeric data. In other words, it is not uncommon for a few errors to be responsible for the majority of changes in the estimates. Consider editing in a selective manner to achieve potential efficiency gains (Granquist and Kovar, 1997), without detrimental impact on data quality. Priorities may be set according to types or severity of error or according to the importance of the variable or the reporting unit.

- For business surveys, put in place a strategy for selective follow-up. The use of a score function (Latouche and Berthelot, 1992) concentrates resources on the important sample units, the key variables, and the most severe errors.

- Keep in mind that the usefulness of editing is limited, and the process can in fact be counter-productive (see, for example, Linacre and Trewin, 1989). Often, data changes based on edits are erroneously considered as data corrections. It can be argued that a point in time is reached during the editing process when just as many errors are introduced as are corrected through the process. Identify and respect this logical end of the process.

- Automation allows and temps survey managers to increase the scope and volume of checks that can be performed. Minimize any such increases if they make little difference to the estimates from the survey. Instead of increasing the editing effort, redirect resources into activities with a higher pay-off (e.g., data analysis, response error analysis.)

- Limit the reliance on editing to fix problems after the fact, especially in the case of repeated surveys. The contribution of editing to error reduction is limited. While some editing is essential, reduce its scope and redirect its purpose. Assign a high priority to learning from the editing process. To reduce errors, focus on the earlier phases of data collection rather than cleaning up at the end. Practice error prevention rather than error correction. To this end, move the editing step to the early stages of the survey process, preferably while the respondent is still available, for example, through the use of computer-assisted telephone or personal or self-interview methods.

- Edits cannot possibly detect small, systematic errors reported consistently in repeated surveys, errors that can lead to serious biases in the estimates. "Tightening" the edits is not the solution. Use other methods, such as traditional quality control methods, careful analysis and review of concepts and definitions, post-interview studies, data validation, data confrontation (see Section 2.17) with other data sources that might be available for some units, etc., to detect such systematic errors.

- Identify extreme data values in a survey period or across survey periods (this exercise is known as the outlier detection process). The presence of such outlying data is a warning sign of potential errors. Use simple univariate detection methods (Hidiroglou and Berthelot, 1986) or more complex and graphical methods (de Waal, 2000).

- When conducting follow-ups, do not overestimate the respondents' ability to report or correct reports. Their aggregations may be different, their memory limited, and their "pay-off" negligible. Limit respondent follow-up activity.

- Do not underestimate the ability of the editing process to fit the reported data to the models imposed by the edits. There exists a real danger of creating spurious changes just to ensure that the data pass the edits. Control the process!

- The editing process is often very complex. When editing is under the Agency's control, make available detailed and up-to-date procedures with appropriate training to all staff involved, and monitor the work itself. Consider using formal quality control procedures.

- Editing can serve a useful purpose in tidying up some of the data, but its much more useful role derives from its ability to provide information about the survey process, either as quality measures for the current survey or to suggest improvements for future surveys. Consider editing to be an integral part of the data collection process in its role of gathering intelligence about the process. In this role, editing can be invaluable in sharpening definitions, improving the survey vehicle, evaluating the quality of the data, identifying nonsampling error sources, serving as the basis of future improvement of the whole survey process, and feeding the continuous learning cycle. To accomplish this goal, monitor the process and produce audit trails, diagnostics and performance measures, and use these to identify best practices.

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2.9 Imputation

Scope and purpose

Imputation is the process used to determine and assign replacement values for missing, invalid or inconsistent data that have failed edits. This is done by changing some of the responses or assigning values when they are missing on the record being edited to ensure that estimates are of high quality and that a plausible, internally consistent record is created. Many of these problems would have been solved earlier through follow-up with the respondent or through review and manual correction of the questionnaire. However, it is generally impossible to resolve all problems at these early stages due to concerns of response burden, cost and timeliness. Since it is usually desirable to produce a complete and consistent microdata file containing imputed data, imputation is used to handle the remaining edit failures.

Although imputation can improve the quality of the final data by correcting for missing, invalid or inconsistent responses, care must be exercised in choosing an appropriate imputation methodology. Some methods of imputation do not preserve the relationships between variables and can actually distort underlying distributions. Therefore, imputation must be taken into account when producing estimates and their associated variance estimates.

Principles

Imputation is best done by those with full access to the microdata and in possession of good auxiliary information. It may be automated, manual or a combination of both. Good imputation attempts to limit the bias caused by not having observed all of the desired values, has an audit trail for evaluation purposes and ensures that imputed records are internally consistent. Good imputation processes are automated, objective, reproducible and efficient. Under the Fellegi-Holt principles (1976), changes are made to the minimum number of fields to ensure that the completed record passes all of the edits.

Imputation methods can be classified as either deterministic or stochastic, depending upon whether or not there is some degree of randomness in the imputed data (Kalton and Kasprzyk, 1986; Kovar and Whitridge, 1995). *Deterministic imputation* methods include logical imputation, historical imputation, mean imputation, ratio and regression imputation and single donor nearest-neighbour imputation. These methods can be further divided into methods that rely solely on deducing the imputed value from data available for the nonrespondent and other auxiliary data (logical and historical) and those that make use of the observed data for other responding units for the given survey. Use of observed data from responding units can be made directly by transferring data from a chosen donor record or by means of models (ratio and regression). *Stochastic imputation* methods include the hot deck, nearest neighbour imputation where a random selection is made from several “closest” nearest neighbours, regression with random residuals, and any other deterministic method with random residuals added.

Guidelines

- Evaluate the type of nonresponse. That is, try to determine which auxiliary variables can explain the nonresponse mechanism(s) in order to use them to enrich the imputation method. Include such auxiliary variables in the imputation method.

- Carefully develop and test the imputation approach. Study the quality and appropriateness of available variables to determine which ones to use as auxiliary variables, as matching variables or to build imputation classes. For this purpose, consult subject matter experts and use modelling techniques.

- Take into account the type of estimates to be produced, such as level vs. change, high-level aggregates vs. small domains, and cross-sectional vs. longitudinal.

- Try to have the imputed record closely resemble the failed edit record. This is achieved by imputing the minimum number of variables in some sense, thereby preserving as much respondent data as possible. The underlying assumption is that a respondent is more likely to make only one or two errors rather than several, although this is not always true in practice. Make imputed records internally consistent.

- In some surveys, it is necessary to use several different types of imputation methods. This is usually achieved in an automated hierarchy of methods. Limit the number of such levels and carefully develop and test the methods used at each level of the hierarchy. Similarly, when collapsing imputation classes is required, carefully develop and test the imputation methods for the new classes.

- When donor imputation is used, try to impute data for a record from as few donors as possible. Operationally, this may be interpreted as one donor per section of questionnaire, since it is virtually impossible to treat all variables at once for a large questionnaire. Also, based on available donors, allow equally good imputation actions an appropriate chance of being selected to avoid artificially inflating the size of certain groups in the population.

- For large surveys, it may be necessary to process variables in two or more passes, rather than in a single pass, so as to reduce computational costs. As well, there may be extensive response errors on a record. Either of these conditions can make it difficult to follow the guidelines exactly: there may be cases where more than one donor is required, and more than the minimum number of variables are imputed.

- During the development of the imputation methodology, note that there exist a number of generalized systems that implement a variety of algorithms, for either continuous or categorical data. The systems are usually simple to use once the edits are specified, and they include algorithms to determine which fields to

impute. They are well documented and retain audit trails to allow evaluation of the imputation process. Two systems currently available at Statistics Canada are the Generalized Edit and Imputation System (GEIS/BANFF) (Kovar et al, 1988; Statistics Canada, 2000a) for quantitative economic variables and the Canadian Census Edit and Imputation System (CANCEIS) (Bankier et al, 1999) for qualitative and quantitative variables.

- Flag imputed values and clearly identify the methods and sources of imputation. Retain the unimputed and imputed values of the record's fields for evaluation purposes. Evaluate the degree and effects of imputation. Consider the use of techniques to adequately measure the sampling variance under imputation and to measure the added variance introduced by imputation (Lee et al, 2002). This information is required to satisfy Statistics Canada's Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2).

- Consider the degree and impact of imputation when analyzing data. The imputation methods used may have a significant impact on distributions of data. For example, it is possible that not very much has changed at the aggregate level, but that values in one domain have moved systematically up, while values in another domain have moved down by an offsetting amount. As well, even when the degree of imputation is low, changes to individual records may have a significant impact, for example when changes are made to large units or when large changes are made to a few units. In general, the greater the degree and impact of imputation, the more judicious the analyst needs to be in using the data. In such cases, analyses may be misleading if the imputed values are treated as observed data.

- Note that the Imputation Bulletin produced by the Methodology Branch presents Statistics Canada's software and practices in imputation as well as recent developments in the field of imputation. Also, the Committee on Practices in Imputation (CoPI) meets regularly to discuss issues related to imputation and specific implementations of imputation. Valuable comments and suggestions can be obtained from the CoPI when designing an imputation strategy.

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2.10 Estimation

Scope and purpose

Estimation is a process that approximates unknown population parameters using only that part of the population that is included in a sample. Inferences about these unknown parameters are then made, using the sampled data and associated design. Where population parameters are functions of population totals, their estimators are generally corresponding functions of the estimated population totals. Examples of parameters include simple descriptive statistics such as totals, means, ratios and percentiles, as well as more complicated analytical statistics such as regression coefficients.

Measures of *precision* are usually computed to evaluate the quality of a population parameter estimate and to obtain valid inferences. Although the quality of the computed estimates is in large part dependent on the preceding survey steps, the choice of an estimation method also plays an important role. In particular, auxiliary data can be used judiciously to improve the precision of these estimates.

Principles

A typical survey objective is to estimate a descriptive population quantity using the sample. The *total survey error* in the estimate is the amount by which the estimate differs from the true value of the quantity for the survey population (Thompson, 1997). The total survey error can be written as the sum of the *sampling error* and *nonsampling error*. The sampling error represents the error associated with estimating a parameter of interest using data from only a sample. Nonsampling errors reflect other reasons for having an imperfect estimator. These include coverage errors (imperfect frame), measurement errors and nonresponse errors.

The estimation method and the sampling design determine the properties of the sampling error. Criteria to evaluate the magnitude of the sampling error include the sampling bias and the sampling variance. Estimation methods that result in both the smallest bias and the smallest sampling variance should be chosen. Design consistency is another desirable property of an estimate.

The basic design-consistent *Horvitz-Thompson estimator* is the most natural estimator to use if there is no auxiliary information available at the estimation stage. It weights data with the inverses of the inclusion probabilities of the sampled units. Such a weight is called a *sampling weight.* The sampling weight can be interpreted as the number of times that each sampled unit should be replicated to represent the full population.

The properties of the Horvitz-Thompson estimator can be improved when auxiliary information is available. C*alibration* is a procedure that can be used to incorporate auxiliary data. This procedure adjusts the sampling weights by multipliers known as *calibration factors* that make the estimates agree with known totals. The resulting weights are called *calibration weights* or *final estimation weights.* These calibration

weights will generally result in estimates that are design consistent, and that have a smaller sampling variance than the Horvitz-Thompson estimator.

If there is nonresponse, the observed sample is smaller in size than the original sample selected. To compensate for nonresponse, imputation (see Section 2.9) or *reweighting* can be performed. Reweighting consists of adjusting the sampling weights by nonresponse adjustment factors before applying the calibration technique. The basic principle in computing the nonresponse adjustment factors is to use the inverse of the response probabilities. However, response probabilities are unknown and must be estimated, as opposed to inclusion probabilities, which are known. The key to reducing nonresponse bias and nonresponse variance is to obtain a useful nonresponse model by taking advantage of the auxiliary information available, as much as possible.

Guidelines

- Proper estimation conforms to the sampling design. To that end, incorporate sampling weights in the estimation process. This implies that aspects of the sampling design such as stratification, clustering, and multi-phase or multi-stage information are reflected in the estimation of parameters and their associated variance estimators.

- Use auxiliary data whenever possible to improve the reliability of the estimates. Evaluate the use of the auxiliary data. This can be done by exploration, using, for example, Statistics Canada's Generalized Estimation System (GES), which is based on regression fitting techniques.

- Whenever auxiliary data are available for sample units, together with known population totals for such data, consider using calibration estimation so that the weighted auxiliary data add up to these known totals. This may result in improved precision and lead to greater consistency between estimates from various sources. Try to constrain the range of the weights resulting from the calibration. A large heterogeneity of weights can lead to an increase in the variance of the estimates, and hence a decrease in their precision. Reducing the range of the weights can be achieved by bounding the weights (Huang and Fuller, 1978; Deville and Särndal, 1992). These bounding methods can also be used to avoid negative or excessively large weights. Singh and Mohl (1996), Stukel et al (1996), and Fuller (2002) discuss the use of auxiliary data in detail.

- When the original classification of sampling units has changed between the time of sample selection and estimation, consider *domain estimation* so that the new classification is reflected in the estimates. Domain estimation refers to estimation for specified subsets of the population (or *domains*) of interest. Often the units falling in these subsets have not been, or could not have been, identified before sampling. Estimation in the presence of dead or out-of-scope units in the sample is an example of domain estimation. These units are assigned a value of zero in the estimation process (Hidiroglou and Laniel, 2001).

- Since the quality of nonresponse adjustment factors in the weights depends on model assumptions, validate the chosen model through several diagnostics and make sure not to forget auxiliary variables correlated with the propensity to respond. This will ensure some protection against nonresponse bias. To obtain some robustness against a model failure, form nonresponse adjustment classes and estimate the response probabilities by the response rates within these classes. Use auxiliary variables correlated with the propensity to respond in the formation of these classes. Some methods for forming homogeneous classes are discussed in Eltinge and Yansaneh (1997). Two-phase sampling theory can be used to estimate the variance for various estimators incorporating the nonresponse adjustments. For example, such procedures are provided in chapter 15 of Särndal, Swensson and Wretman (1992). Knowledge Seeker is a software package that can be used to form homogeneous classes using the methodology described in Kass (1980).

- When appropriate, use double sampling to improve estimation by incorporating auxiliary data. These are data that are available for the universe and/or the larger sample (the first-phase sample in the case of two-phase sampling). Double sampling can be used (a) to stratify the second-phase sample, (b) to improve the estimate using a difference, ratio or regression estimator, or (c) to draw a sub-sample of nonresponding units. A fairly general approach to two-phase sampling when auxiliary data are incorporated in the estimation process via the Generalized Regression Estimator (GREG) of total is presented in Hidiroglou and Särndal (1998). In the case of double sampling, Hidiroglou (2001) provides a general theory when auxiliary data are incorporated in the estimation process via optimal regression estimators of totals.

- The sampling of units of interest may be indirect. That is, the sample of a frame of interest (representing the survey population) may be selected only via units belonging to another frame. If linkages can be established between the units of the two frames, obtain inference about the survey population by computing estimation weights for the surveyed units. These weights can be computed using the Generalised Weight Share Method given in Lavallée (2002).

- Keep in mind that for longitudinal surveys, two sets of estimation weights are usually provided: the longitudinal weights and the cross-sectional weights. The longitudinal weights refer to the population at the initial selection of the longitudinal sample. These weights are usually adjusted to take into account the attrition of the sample over time. The longitudinal weights are used when performing analysis of the longitudinal data. The cross-sectional weights are related to the population established at each survey wave. These weights are normally used to produce point estimates, or differences of point estimates between two time periods. Because of the changes in the population through time, the cross-sectional weights are generally different from the longitudinal weights.

- In periodic surveys with a large sample overlap between occasions, consider the use of estimation methods that exploit the correlation over time (Binder and

Hidiroglou, 1988; Singh, Kennedy and Wu, 2001). One of these estimation methods is referred to as *composite estimation*. These methods basically treat the data from previous occasions as auxiliary variables.

- Incorporate the requirements of small domains of interest at the sampling design and sample allocation stages (Singh, Gambino and Mantel, 1994). If this is not possible at the design stage, or if the domains are only specified at a later stage, consider special estimation methods (small area estimators) at the estimation stage. These methods "borrow strength" from related areas (or domains) to minimize the mean square error of the resulting estimator (Platek et al., 1987; Ghosh and Rao, 1994; Rao, 1999).

- Outliers often lead to unreliable estimates for continuous variables. Outliers might be due either to extreme values measured for some characteristics, or to very large weights attached to the outlying elements, or both. Consider using objective procedures such as outlier-resistant (robust) estimators (Hidiroglou and Srinath, 1981; Fuller, 1991; Lee, 1995; Duchesne 1999; Gwet and Lee, 2000; Chambers, Kokic, Smith and Crudas, 2000). In the case of multivariate outliers, the use of Mahalanobis' Distance and Stahel-Donoho Estimators, adapted to the survey design, is recommended (Patak, 1990; Franklin, Thomas and Brodeur, 2000).

- Whenever possible, use generalized estimation software instead of tailor-made systems. Possible software packages to use include GES (Estevao, Hidiroglou and Särndal, 1995), SUDAAN 8.0 (Shah, et al., 1997), PC CARP (Schnell, et al., 1988), WesVar PC (Brick, et al., 2000), STATA (1997), and SAS 8.0. By using generalized systems, one can expect fewer programming errors, as well as some reduction in development costs and time.

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2.11 Seasonal adjustment and trend-cycle estimation

Scope and purpose

Seasonal adjustment consists of estimating seasonal factors and applying them to a time series to remove the *seasonal variations*. These variations represent the composite effect of climatic and institutional factors that repeat with a certain regularity within the year. The seasonally adjusted series consists of the trend-cycle and the irregular components. The *trend* is the underlying long-term movement lasting many years. The *cycle*, usually called the business-cycle, is a quasi-periodic oscillation lasting from three to four years. The *irregular component* represents those random variations that are unforeseeable movements related to events of all kinds.

Statistical agencies publish many of their series in seasonally adjusted form to reveal the underlying trend-cyclical movements and to help data analysis. Seasonally adjusted series comprise not only the trend-cycle but also the irregular component; consequently, they only give an approximate idea of the underlying trend-cyclical movements. Smoothing the seasonally adjusted series further is often desirable to eliminate the irregular component and to publish *trend-cycle estimates* as a complement to the seasonally adjusted series.

This section is a transcript of the Agency's Guidelines for Seasonal Adjustment and Trend-Cycle Estimation (Statistics Canada, 2000b).

Principles

Seasonally adjust a time series only when there is evidence that the series is influenced by seasonal forces, and when the series contains identifiable seasonality. Identifiable seasonality is defined as a seasonal pattern that is not obscured by a high degree of irregular fluctuations and thus can be identified reliably (Lothian and Morry, 1978).

A good seasonal adjustment procedure does not leave any residual seasonality in the series, and the resulting seasonally adjusted series is much smoother than the original.

The revisions to the seasonally adjusted estimates should be minimal as more data points are added to the end of the series. The X11ARIMA (Dagum, 1980) and the X11ARIMA/88 (Dagum, 1988) seasonal adjustment methods were adopted by Statistics Canada with the exact purpose of reducing the size of revisions (Dagum, 1975; Kuiper, 1976; Dagum, 1982).

The frequency of revisions should be minimized. Although revisions arise with each new data point added, implement revisions only when they bring about improvement in the estimates, that is, when the revised estimate moves appreciably closer to the final estimate.

Wherever seasonally adjusted figures pertaining to the same economic activity are published, coordinate the seasonal adjustment options applied by the areas involved, and make every effort to treat related series in a consistent manner.

When trend-cycle estimates are produced as a complement to the seasonally adjusted series it is important to keep in mind that they are used for providing a reading of the stage of the business cycle, and therefore their accuracy is important with regard to the direction of movement, the amplitude of the cycle and especially the timing of turning points.

The trend-cycle estimates should be consistent with the published seasonally adjusted estimates. If the latter estimates are frozen in the database after three months, apply the trend-cycle estimator to the seasonally adjusted estimates as they appear on the base and in the publication.

Guidelines

- Before seasonally adjusting a series for the first time, and after that every few years, conduct a thorough seasonal analysis to assess if seasonality is identifiable and publish the series in seasonally adjusted form only if it is identifiable.

- During seasonal adjustment it is recommended that ARIMA extrapolations be used in the calculations of the seasonal factors to reduce the size of the revisions. Use the automatic ARIMA extrapolation subroutine of the X11ARIMA program whenever possible. If none of the built-in models is selected, it is recommended that the user supply an ARIMA model.

- For the seasonal adjustment of recent observations, use a *concurrent seasonal factor* (Dagum, 1987). This is a factor obtained using all the available data points. An exception to this guideline may apply when the most recent observations have been subjected to historically large revisions. In this case *year-ahead (forecast) seasonal factors* may be more appropriate (Morry, 1992). These seasonal factors are based on data that ended at the end of the previous year.

- When a concurrent seasonal factor is used, it is not necessary to revise the seasonally adjusted estimates more than one period back when the next observation becomes available. An exception to this guideline applies when preliminary observations are used: it is recommended to revise the seasonal factors whenever the original figures are revised significantly. On an annual basis, revise the seasonally adjusted values for the last three years when the first month (quarter) of the next year becomes available (Dagum, 1987). When seasonally adjusted values are obtained with year-ahead (forecast) seasonal factors, the annual revision applies to the last four years.

- For series with trading-day variations, use the daily weights that are automatically estimated by the X11ARIMA program. During the current year, keep them fixed

by supplying them as prior daily weights. They will be modified at the next annual revision. Exceptions to this guideline may occur when a-priori daily weights can be provided by subject matter experts based on better knowledge of the series in question.

- For series with Easter variations, use the Easter effect factors calculated automatically by the X11ARIMA program.

- For aggregate series resulting from the combination of component series, seasonally adjust only those component series that contain identifiable seasonality, and leave the others unadjusted. Seasonally adjust the aggregate series by the indirect or direct method. In the indirect method, combine the seasonally adjusted components and the unadjusted ones to obtain the seasonally adjusted aggregate. In the direct method, seasonally adjust the aggregate, and restore additivity (if required) by raking the components, if possible without modifying the unadjusted ones. When choosing between the indirect and the direct approach the following factors need to be considered: the aggregate should not contain residual seasonality and it should be relatively smooth (Lothian and Morry, 1977). Choose the raked direct approach only if the raking does not distort too much the month-to-month (quarter-to-quarter) movements of the component series.

- Wherever seasonally adjusted figures pertaining to the same economic activity are published, coordinate the seasonal adjustment options applied by the areas involved. For example, when possible, make consistent choices between direct and indirect adjustment of composite series, and ensure that extreme occurrences in the time series brought about by events such as plant closures, strikes, natural disasters, etc. are treated in a consistent fashion by the different areas.

- Use the Henderson moving averages, available in the X11ARIMA program, to produce the trend-cycle estimates. To ensure that the trend-line lies within the scatter plot of the seasonally adjusted series, apply the Henderson moving averages to the published seasonally adjusted series.

- Before applying the trend-cycle estimator, extend the seasonally adjusted series with one year of forecasted values from an ARIMA model fitted to the seasonally adjusted series.

- Apply the Henderson moving averages to the extended seasonally adjusted series from which the extremes have been previously corrected.

- Use the Henderson moving average automatically selected by the X11ARIMA program: the selection is based on the value of the I/C (irregular to trend-cycle) ratio, which measures the relative importance of the irregular variations in the seasonally adjusted series (Shiskin, et al., 1967).

- Inform the users that the last few trend-cycle estimates (and especially the very last estimate) are subject to large revisions, and often to a reversal of movement when one more data point is added to the series (Dagum and Laniel, 1987). This high uncertainty associated with the estimates around the end can be indicated, for example, by a dashed line on the trend graph or by a written caveat to users.

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2.12 Data quality evaluation

Scope and purpose

Data quality evaluation is a process used to determine whether final products meet the original objectives of the statistical activity, in particular in terms of that data's accuracy, timeliness and reliability. It allows users to better interpret survey results and the Agency to improve the quality of its surveys.

There are two broad methods of evaluating data quality:

Certification or *validation* is the process whereby data are analysed before official release with a view to avoiding gross errors and eliminating poor quality data. This process frequently coincides with an interpretative analysis of the data and usually involves time constraints and deadlines, and therefore only methods that yield rapid results can be used.

Sources of error studies generally provide quantitative information on the specific sources of errors in the data. While timeliness is important, the results of these studies often are only available after the official release of the data.

Principles

Users must be able to determine to what extent data errors affect their use; however, users are rarely able to independently evaluate the accuracy of data produced by a statistical agency. It is therefore up to each agency to evaluate data quality and quickly provide users with the results in a usable form.

Data quality evaluations are also useful to the Agency. To the extent that errors can be associated with certain stages of the survey process, evaluations can be used to improve the quality of the next iteration of the survey, as well as other similar surveys. Evaluations include, for instance, reviewing survey plans, the significance of nonresponse, as well as dubious imputation practices.

The timeliness of data quality evaluations is just as important as the timeliness of the data. Ideally, evaluation results are valid and timely enough to improve released data -- for example: an evaluation of coverage can be used to compensate for differences between the frame and the target population. When this is not possible, evaluation results should at least be timely enough to help users to analyse the data and staff to design the next iteration of the survey.

Guidelines

- Determine the extent of data quality evaluation required for a program or a product. The factors to be considered are: data uses and users; risk of errors and impact of errors on data use; quality variation over time; cost of the evaluation in relation to the total cost of the program; improving quality; increasing efficiency

and productivity; usefulness of measures to users and ease of interpretation; and whether the survey will or will not be repeated.

- Data quality evaluations at Statistics Canada must be designed to meet the mandatory and minimum requirements of the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2). In the case of census and survey data, minimum requirements include measuring or evaluating coverage errors, response or imputation rate and (if dealing with a sample survey) measurement of sampling errors for key characteristics.

- Provide a quality evaluation based on expert opinion or subjective analysis whenever data quality evaluations will not yield quantitative measurements because of the nature of the product, the user, time constraints, cost or technical feasibility.

- Make planning of data quality evaluations part of the overall survey design, as the information needed for such evaluations must often be collected during the survey process. Data quality reports should be included in the dissemination schedule for the survey.

- In the case of repeated surveys and statistical activities, it may not be necessary, or even possible, to consistently produce detailed quality evaluations. However, periodically review activity to ensure it meets its objectives – not just when problems arise.

- Involve users of evaluation results, whether they are associated with a statistical agency or not, in establishing the data quality evaluation program objectives. When circumstances permit, also involve them in the evaluation process.

- Among certification methods, consider:
  - checking coherence in relation to external data sources – for example: other surveys, other iterations of the same survey, administrative data
  - checking internal coherence – for example: by calculating ratios that are known to be within certain limits (male-female ratios, average values of properties, etc)
  - analysing largest units individually as regards their contributions to overall estimates (generally applied to business surveys)
  - calculating data quality indicators – for example: nonresponse rates, imputation rates and coefficients of variation
  - holding feedback sessions with staff involved in data collecting and processing
  - "reasonableness" checks by well-informed experts, including pre-release external review in the form of “work in progress.”

- Evaluate the following sources of error:
  - *Coverage errors* which consist of omissions, erroneous inclusions, and

duplications in the frame used to conduct the survey. Since they affect all survey estimates, they constitute one of the most important types of error. Coverage errors may translate into a negative or positive bias in the data, and the impact may vary depending on the survey universe subgroup. One should also be concerned about classification errors, notably industrial and geographical, among others. For example, badly defined limits or erroneous coding may lead to an omission of part of the territory.

- *Nonresponse errors* occur when there is no response to one or all of the survey questions. Nonresponse leads to an increase in variance as a result of a reduction in the actual size of the sample and the recourse to imputation, and produces a bias if the nonrespondents have characteristics of interest that are different from those of the respondents. Furthermore, there is a risk of significantly underestimating the sampling error, if imputed data are treated as though they were observed data.
- *Measurement errors* occur when the response provided differs from the real value; such errors may be attributable to the respondent, the interviewer, the questionnaire, the collection method or the respondent's record-keeping system. Such errors may be random or they may result in a systematic bias if they are not random.
- *Processing errors* occur at subsequent stages of the process, when checking, coding, entering, imputing, and tabulating data. Like measurement errors, processing errors may lead to variance and bias. It is also necessary to look into the potential impact of snags in the survey process: uneven staff training, unusually high staff turnover, procedural changes in mid-operation, etc.
- *Sampling errors* occur when survey results were obtained from a sample rather than the population as a whole. In practice, these errors may also include *estimation errors* that may be attributable to the use of estimators which, deliberately or otherwise, create a bias (e.g., some small area estimators).

A good discussion of the subject can be found in Lessler and Kalsbeek (1992) and Lyberg et al (1997).

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2.13 Disclosure control

Scope and purpose

Statistics Canada is obligated by law to protect the *confidentiality* of respondents' information. *Disclosure control* refers to the measures taken to protect the Agency's data in a way that the confidentiality requirements are not violated. The direct impact of disclosure control activities on the quality of the data is usually a limiting one, in that some data detail may have to be suppressed or modified. The goal is thus to ensure that the confidentiality protection provisions are met while preserving the usefulness of the data outputs to the greatest extent possible. Statistics Canada's vigilant disclosure control/confidentiality protection program has made a significant contribution to the quality of the Agency's data and has resulted in high response rates the Agency's surveys enjoy and in the public's confidence in the Agency as a whole.

Principles

The principles of disclosure control activities are governed, almost entirely, by the legal provisions of the *Statistics Act* (1970, R.S.C. 1985, c. S19), specifically by subsection 17(1) which reads as follows:

> "no person who has been sworn in under section 6 shall disclose or knowingly cause to be disclosed, by any means, any information obtained under this Act in such a manner that it is possible from the disclosure to relate the particulars obtained from any individual return to any identifiable individual person, business or organization."

However, subsection 17(2) does provide for the release of selected types of confidential information at the discretion of the Chief Statistician and by order. The most common types of such releases are lists of businesses with their addresses and industrial classifications or information relating to an individual respondent if that respondent has consented to the disclosure in writing. The release of information using the Chief Statistician's discretion is governed by the Policy on Discretionary Release (Statistics Canada, 1993a) and, in some cases, by the Guidelines on the Release of Unscreened Microdata under the Terms of Section 12 Data Sharing Agreements or Discretionary Release Provisions.

The confidentiality provisions of the Statistics Act are extremely rigorous. Consequently, the translation of their meaning to specific applications is, in practice, a difficult but extremely important task. The primary goal is to ensure that no identifiable individual return's data can be inferred to within a narrow range. Furthermore, it is necessary to protect information whether or not it concerns something likely to be considered sensitive by respondents; thus, basic demographic characteristics must be protected, just as much as income. It is important to note that there is no reference in the legislation to any time limits on the protection of information from disclosure. As well, the public perception that the Agency is vigilant in protecting the confidentiality of its data holdings is as

important as the reality of what the Agency actually does to protect respondents' data from being disclosed.

Guidelines

- Distinguish between *tabular data* and *microdata releases*. In the case of tabular data, the data are released in the form of statistical tables, sometimes over many dimensions, whereas for microdata, anonymized records for individuals are produced. Tabular data can be classified into *frequency tables* or *tables of magnitudes*. Frequency tables give only counts (or estimated counts) of the number of units that fall into each of the cells of the table, whereas tables of magnitudes give numeric (usually non-negative) values, such as means or totals of dollar values, or number of employees in each cell. Measures that ensure confidentiality protection for these diverse products are necessarily very different.

- Do not release a table of magnitude data if it provides values for cells that are considered to be sensitive. The criteria for sensitivity are usually based on simple rules that are generally believed to guard against disclosure of an individual respondent's characteristics.

- Determine the sensitivity of each cell. Two criteria are usually used. One is the number of respondents in the cell, and the other is based on measures of concentration or predominance of the distribution of the respondents' values within the cell. An example of the former is simply that the number of respondents in a cell must exceed some minimum value. For many surveys, tables with cells having only three respondents may be released. Less than three is unacceptable, since if there are only two respondents, then one of the respondents could derive the value for the other respondent by simple subtraction.

- There are many cell suppression rules that are based on measures of concentration. Determine which concentration measure is to be used. The easiest ones to implement are rules that are based on linear combinations of order statistics. One such common rule is known as the *(n,k) rule*. In this case, a cell is sensitive if the largest n respondents in it account for at least k% of the total cell value. Often more than one value of n is controlled, say n=1 or 2. In some cases, different values of k are used according to the number of respondents in the cell, but this is not advisable, since the addition of a new respondent with negligible contribution could change a sensitive cell into a non-sensitive one, which is intuitively unreasonable. This is due to the discontinuity of the rules.

- The *p-percent rule* is also based on a measure of concentration (Subcommittee on Disclosure Limitation Methodology, 1994). It is meant to ensure that a coalition of units, typically the unit with the second-largest value, cannot estimate the largest unit’s value too closely. An example of such a rule, with p=15, would be to declare a cell sensitive if the sum of the values of the third largest and all lower ranking respondents' values was less than 15% of the largest respondent’s value.

An extension of the p-percent is the *pq rule*, where the value q ($p<q<100$) represents the organization's estimate as to how accurately respondents can determine other units' values. A pq rule with p=15 and q=60 is equivalent to a p-percent rule with p=25.

- Determine if zero frequency cells represent a problem. Zero frequency cells may reveal sensitive information in tables of magnitude data.

- Delete sensitive cells from a table. Such corrective action is known as *cell suppression*. A problem arises, however, because suppressing only the sensitive cells is often not sufficient when marginal totals are also released, because it may be possible to obtain the exact value of the suppressed cell by solving a system of linear equations. Even if this is not possible, one can derive a range of values for the suppressed cell, through linear programming methods, and this range may be deemed to be too narrow to give ample protection to the suppressed value. As a result, find complementary cells to suppress in order to protect the sensitive cell. The problem of finding complementary cells is further complicated by the possible presence of hierarchies in the table classification variables (e.g., different levels of industrial coding) and the output of sets of related tables. Sophisticated software exists to identify complementary cells, although not all such packages address the issues of hierarchies and related tables adequately.

- Consider alternative methods to cell suppression. One method is to change the row and column definitions, by *collapsing* categories, by regrouping or by *top coding* the category values, so that none (or fewer) of the cells are sensitive. Other possible methods include perturbing data through the addition of noise to the microdata, or the addition of noise to the tabular data, such as rounding. Any procedure to make the underlying microdata file safe could be used to protect the tabular data, and then all tabulations would be run from the "safe" microdata file.

- Rounding the cell values can take a number of different forms. Often conventional or deterministic rounding will not add enough noise to give sufficient protection. Consider the use of random rounding.

- In frequency tables, low frequency cells may be problematic. Individuals in such cells may be easily identified, so that it becomes known that all other members of the population belong to some other cell. It is certainly true that if only one cell in a given row or column is non-zero, and the membership of such a row or column is known, then disclosure has taken place. When necessary, implement controls to prevent the distributions for given rows or columns from being concentrated in a small number of categories. In particular, when columns (or rows) define ranges of a magnitude variable, say income, ensure that the nonzero cells in each row (column) span a sufficiently large range of possible values for income.

- Techniques for reducing the disclosure risk in frequency tables include all those used for magnitude tables, that is, cell suppression; changing the row and column

definitions by collapsing categories or by regrouping or top coding the category values; perturbing data through the addition of noise to the microdata or the addition of noise to the tabular data, such as rounding; and other procedures that make the microdata file from which the tabulations are run safe from disclosure.

- Ensure that all releases of public use microdata files are reviewed by The Microdata Release Committee (Statistics Canada, 1987).

- In the case of microdata releases, individual records rather than aggregated data are being published, and the disclosure criteria for such files are very different. Even though microdata files do not contain identifying information such as names and telephone numbers, they contain a number of variables, called *key variables*, that, in combination, can serve to identify unique individuals in the population who may be on the file. Identification would be equivalent to a disclosure of the microdata characteristics for these individuals. Note that, even if the individuals identified are not truly unique, or if they have been wrongly identified, the appearance of a disclosure can sometimes be as harmful to the Agency as an actual case of disclosure.

- Assess the risk of disclosure for microdata files. The number and nature of key variables can affect the disclosure risk. Some identifying characteristics, such as detailed geography or exact income, are considered to present a higher disclosure risk. On the other hand, a lower level of quality, such as the presence of measurement errors or of imputed values, can lower the risks associated with certain characteristics. Disclosure risks increase with the sampling rate, and microdata should not be released for a 100% sample. Similarly, microdata files should not contain 100% samples within identifiable strata or sub-groups. Characteristics of the surveyed population itself can also affect the disclosure risk. Microdata files for businesses are rarely released because of the concentrated nature of business data. The presence of hierarchical relations between units can also affect the disclosure risk.

- There are two general methods to control the disclosure risk for microdata files. *Data reduction methods* include sampling, ensuring that the populations for certain identifiable groups are sufficiently large, making the variable categories wider, top and bottom coding, removing some of the variables from some respondents, or removing some of the respondents from the file. *Data modification methods* include adding random noise to the microdata, data swapping, replacing small groups with average values, or deleting information from some respondents and replacing it with imputed values.

- An even more difficult problem arises when dealing with strategies to release microdata files from longitudinal surveys. In this case, determine an appropriate strategy before the longitudinal survey has run its full course. This implies that the strategy must be defined in the absence of the full survey results, that is, prior to collecting the data for future waves of the survey. Since one of the objectives of

this strategy is to define the variables to be released and their respective categorization, certain assumptions need to be made about how these variables evolve over time, and whether this evolution can lead to certain variables becoming key variables.

- Data reduction and data modification methods are known as *restricted data methods*. As an alternative to releasing microdata files, consider using *restricted access* methods such as remote access or research data centres. Under remote access, researchers do not have direct access to the Agency's survey data, but they can e-mail an analytical program that is run on the microdata residing within the Agency. The program outputs are screened by Agency staff and, if they present no disclosure risk, they are e-mailed to the researcher. Statistics Canada's Research Data Centres are secure settings where researchers with approved projects and who are "sworn-in" as deemed employees under the *Statistics Act* can have access to confidential microdata. The centres operate like extensions of Statistics Canada and are staffed by full-time Statistics Canada employees. Only non-confidential results are allowed to leave the centres.

- Although there are many rules for ensuring confidentiality protection, the rules cannot replace common sense. For example, rules to avoid all residual disclosures resulting from multiple releases from the same basic database are difficult to define, especially in the case of ad hoc requests, so that some manual intervention becomes necessary. There are still many unanswered questions in this area, and research is needed to ensure that as much data can be released as possible, without violating the confidentiality requirements.

- Use generalized disclosure control software instead of custom-built systems whenever possible. Possible software packages to use include the Agency's cell suppression software, CONFID (Statistics Canada, 2002d) or the τ-ARGUS Software (Hundepool et al, 2002). By using generalized systems, one can expect fewer programming errors, as well as some reduction in development costs and time.

- Make use of resources available within Statistics Canada on matters of confidentiality when necessary. Consult the Data Access and Control Services Division on policy matters relating to the confidentiality of the information collected by Statistics Canada, the Confidentiality and Legislation Committee and its subcommittees: Discretionary Release Committee, Disclosure Review Committee, and Microdata Release Committee on issues related to disclosure control strategies and practices, and the Disclosure Control Resource Centre for technical assistance.

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2.14 Data dissemination

Scope and purpose

Dissemination is the release to users of information obtained through a statistical activity. Various release media are possible, for example, Statistics Canada's The Daily; CANSIM II or some other electronic format via the Internet; a paper publication; a microfiche; a microdata file of anonymized survey responses; a telephone or facsimile response to a special request; or a public speech, presentation or television or radio interview. Data mentioned in the "Data availability" notices in The Daily are considered to be released and fall within the scope of these guidelines.

Principles

It is important that attention be paid to the delivery of information to users to ensure that it is accurate, complete, accessible and appropriately priced, understandable, usable, timely and meets confidentiality requirements. Those responsible for dissemination will keep in mind users' needs, exploit technological advances in order to enable users to process the statistical information cost-effectively and efficiently in their own working environments, and consider market expectations, based, for example, on feedback from previous clients, product testing or marketing activities.

Many of the principles and guidelines in the earlier section on data quality evaluation and in the following two sections on data analysis (and presentation) and on documentation are relevant to data dissemination. Several Statistics Canada policies are concerned with dissemination (Statistics Canada, 1985a, 1985c, 1986a, 1986c, 1987, 1988, 1992a, 1992b, 1993a, 1993b, 1994a, 1994b) but are not elaborated upon here except where they relate to quality. Thus, for example, specific policies related to licensing, copyright and announcement in The Daily, although important for data dissemination in general, are excluded from these guidelines.

Guidelines

- Preparation of data to be released from a statistical activity's source file usually involves many steps. Verify and ensure that released data, after all the processing steps, are consistent with the source data obtained. In the case of regrouped data or derived variables this means that one should be able to reproduce the same results from the source data.

- Where data validation by an external organization is necessary and where significant benefits to data quality are anticipated or have been previously demonstrated, unreleased non-confidential information may be provided to external organizations for purposes of validation before its official release in The Daily, under conditions laid down in the Policy on Statistics Canada's Daily (Statistics Canada, 1993b).

- Test an electronic product before release to ensure that it performs as planned.

- Provide data quality measures or, where possible, tools for their calculation (e.g., CV look-up tables, sampling variance programs) along with the disseminated product (Statistics Canada, 2000d; see Appendix 2).

- Provide documentation along with the disseminated material that contains, as appropriate, descriptions of its quality and the methodology used (Statistics Canada, 2000d; see Appendix 2). The documentation may be on paper or in electronic form. When the medium is electronic, provide instructions on how to access the information and data.

- Provide elements of documentation required to the Integrated Metadatabase (Statistics Canada, 2000c) for each survey reference period. The IMDB is Statistics Canada's primary vehicle for implementing its Policy of Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2). The IMDB covers direct, administrative, derived surveys, and a combination of these.

- Develop a dissemination product consistent in style and formatting to other Statistics Canada products: this will assist in its use.

- Provide a contact person, a telephone number and an e-mail address for each release of information. Ensure that prompt and knowledgeable service and support are available during regular working hours.

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2.15 Data analysis (and presentation)

Scope and purpose

Data analysis is the process of transforming raw data into useable information that is often presented in the form of a published analytical article. The basic steps in the analytic process consist of identifying an issue, asking meaningful questions, developing answers to the questions through examination and interpretation of data and communicating the message to the reader.

Analytical results can underscore the usefulness of data sources by shedding light on issues. Some Statistics Canada programs even depend on analytical output as a major data product because, for confidentiality reasons, it is not possible to release the microdata to the public. In recent years there has been emphasis placed on increasing the amount of relevant analysis being done within the Agency with Statistics Canada data.

Data analysis also has an important role as part of the survey development and revision process. It can have a crucial impact on data quality by helping to identify data quality related problems and by influencing future improvements to the survey process. Analysis is essential for understanding results from previous surveys and pilot studies, for planning new statistical activities, for providing information on data gaps, for designing surveys, and for formulating quality objectives.

Principles

A statistical agency is concerned with the relevance and usefulness to users of the information contained in its data. Analysis is the principal tool for obtaining information from the data. Analysis results may be categorized into two general types: (a) descriptive results, which are results relating to the survey population at the time that the data were collected - for example, the median income in the year that the population was surveyed; and (b) analytical results relating to a survey population that often goes beyond the actual population surveyed - for example, the chance of someone having a particular chronic disease.

To be effective, the analyst needs to know the audience and the issues of concern (both current and those likely to emerge in the future) when identifying topics and suitable ways to present results. Study of background information allows the analyst to choose appropriate data sources and statistical methods. Any conclusions presented in an analytical study, including those that can impact on public policy, must be supported by the data being analyzed.

Guidelines

- Ensure that the data are appropriate for the analysis to be carried out. This requires investigation of a wide range of details such as whether the survey population of the survey sufficiently approximates the target population of the

analysis, whether the variables and their concepts and definitions are relevant to the study, whether the longitudinal or cross-sectional nature of the survey is appropriate for the analysis, whether the sample size in the study domain is sufficient to obtain meaningful results and whether the ascertained quality of the data from the survey supports these results.

- If more than one data source is being used for the analysis, investigate whether the sources are consistent and how they may be appropriately combined.

- Consider whether imputed values should be included in the analysis and if so, how they should be handled (see Section 2.9).

- Consider how unit and/or item nonresponse should be handled in the analysis.

- Choose an analytical method that is appropriate for the question being investigated.

- When making comparisons between two groups of individuals, businesses, or other units, control for extraneous factors. If significant differences between the groups are found as a result of statistical tests, then consider alternative plausible explanations for the differences.

- Since most analyses are based on observational studies rather than on the results of a controlled experiment, avoid drawing conclusions concerning causality.

- Use diagnostic techniques to assess the analytical model.

- Beware of focusing on short-term trends without inspecting them in light of medium-and long-term trends. Frequently, short-term trends are merely minor fluctuations around a more important medium- and/or long-term trend.

- Where possible, avoid arbitrary time reference points, such as the change from last year to this year. Instead, use meaningful points of reference, such as the last major turning point for economic data, generation-to-generation differences for demographic statistics, and legislative changes for social statistics.

- Consult with experts both on the subject matter and on the statistical methods.

- Analytical methods that ignore the survey design can be useful, provided the model being assumed in the analysis is correct. However, alternative methods that incorporate the sample design information, frequently called design-based methods, will generally be effective even when some aspects of the model are incorrectly specified. Assess whether the survey design information can be incorporated into the analysis and if so how this should be done. Having determined the appropriate analytical method, investigate the software choices that are available to apply the method. [See Binder and Roberts (2001) for a

definition of ignorable survey designs, and Binder and Roberts (2003) and Skinner, Holt and Smith (1989) for discussion of ignoring the survey design. See Statistics Canada (2003a), Chambers and Skinner (2003), Korn and Graubard (1999), Lehtonen and Pahkinen (1995), Lohr (1999), Thomas (1993), and Skinner, Holt and Smith (1989) for a number of examples showing the benefits of design-based analytical methods.]

- Before beginning to write, prepare an outline of the article. When preparing the outline, consider such questions as: "What issue am I addressing? What data am I using? Can I eliminate any irrelevant data? What analytical methods are appropriate? What results do I want to highlight? What are my interesting findings?"

- Focus the article on the important variables and topics. Trying to be too comprehensive will often interfere with a strong story line.

- Arrange ideas in a logical order and in order of relevance or importance. Use headings, sub-headings and sidebars to strengthen the organization of the article.

- Keep the language as simple as the subject permits. Depending on the targeted audience for the article, some loss of precision may sometimes be an acceptable tradeoff for more readable text.

- Use graphs in addition to text and tables to communicate the message. Use headings that capture the meaning (e.g., "Women's earnings still trail men's") in preference to traditional chart titles (e.g., "Income by age and sex"). Always help readers understand the information in the tables and charts by discussing it in the text.

- When tables are used, take care that the overall format contributes to the clarity of the data in the tables and prevents misinterpretation. This includes spacing; the wording, placement and appearance of titles; row and column headings and other labeling.

- Explain rounding practices or procedures. In the presentation of rounded data, do not use more significant digits than are consistent with the accuracy of the data.

- When presenting details about rates, be careful to distinguish between percentage change and change in percentage points. Define the base used for rates.

- Ensure that all references are accurate and are referred to in the text.

- Check for errors in the article. Check details such as the consistency of figures used in the text, tables and charts, the accuracy of external data, and simple arithmetic.

- Ensure that the intentions stated in the introduction are fulfilled by the rest of the article. Make sure that the conclusions are consistent with the evidence.

- Have the article reviewed by at least two other persons. Where appropriate, verify the quality of the translation.

- As a good practice, consider doing a presentation about the analysis results that have been obtained. This is another kind of peer-review that can help improve the article. Always dry run presentations involving external audiences.

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2.16 Documentation

Scope and purpose

Documentation constitutes a record of the statistical activity, including the concepts, definitions and methods used to produce the data. It also includes descriptions of factors affecting data comparability and quality.

Documentation may serve as a record for users of what was done in order to provide a context for effective and informed use of the data. During implementation, documentation is a means of communication to assure effective development of the statistical activity. In addition, documentation includes not only what decisions were made, but also why they were made, and provides information which will be useful for future development and implementation of the same, a similar or a redesigned statistical activity.

Principles

The goal of documentation is to provide a complete, unambiguous and multi-purpose record of the survey, including the data produced from the survey. Documentation of any step of the survey may be aimed at any of several different groups, such as management, technical staff, planners of other surveys, and users. Documentation should be up-to-date, well organized, easily retrievable, concise and precise. Effective presentation of results is an important part of documentation. Documentation may be multi-media (e.g., paper, electronic, visual), and different documents may be prepared for different audiences and purposes.

Guidelines

- The level of detail provided in the documentation will depend on its intended audience, the type of data collection, the data sources, the analysis, the method of dissemination, the range of uses of the data and their impact, and the total budget of the statistical program. Ensure that all statistical products meet the requirements of the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2).

- Depending on the audience and purpose, documentation may include the following:
  - Objectives: Include information on the objectives and uses of the data, timeliness, frequency, and data quality targets; these may have changed as work proceeded on the survey (for example: owing to budgetary constraints, perceived feasibility, results of new pilot studies, or new technology), and these changes need to be documented because they have an impact on the design of the questionnaire and the analysis of test results.

- Content: Include the questionnaire used and concepts and definitions. In the case of computer assisted interviews, provide the development specifications for the software application. To facilitate integration with other sources, use standardized concepts, questions, processes and classifications. Highlight differences, if warranted. Mention the role of advisory committees and users.
- Tests: Describe cognitive tests, field tests or pilot surveys, and report on results as to how specifications were met, complete with recommendations.
- Methodology: Set out design alternatives. Deal with issues such as target population, frame, coverage, reference period, sample design, sample size and selection, collection method and follow-up procedures for nonresponse, estimation, editing and imputation, benchmarking and revision, seasonal adjustment, confidentiality and evaluation. Emphasize different aspects for different readers. Provide a consolidated document on technical issues for professionals. Provide a methodological overview.
- Systems: Include information on data files (capture method, layouts, explanation of codes, basic frequencies, edit procedures), systems documentation (construction, algorithms, use, storage and retrieval), and monitoring reports (time spent and where, trouble areas, scheduling of runs to determine whether processing is on time).
- Operations: Include or cite references for training manuals, operator and interviewer manuals, feedback and debriefing reports.
- Implementation: Document operations, with inputs and outputs clearly specified. Attach schedules for each implementation step.
- Quality control: Include the instructions and/or a manual for supervisors and editing staff.
- Data quality: For general use, include coverage, sampling error, nonsampling error, response rates, the rates and effects of edit and imputation, comparability over time and with other data, validation studies and any other relevant measures specific to the particular statistical activity. Describe any unexpected events affecting data quality (e.g., floods, high nonresponse). For technical users, include total variance or its components by source, nonresponse and response biases, and the impact and interpretation of seasonal adjustment.
- Resources: List the actual resources consumed, as a function of time. Account for all expenditures in terms of money and time. Comment on expenditures vs. budgets.
- References: Organize and document references (theoretical and general papers and documents relevant to, but not produced as part of, the project).

■ Provide documentation elements required for the Integrated Metadatabase (Statistics Canada, 2000c). As the archive for information on Statistics Canada surveys and programs, the IMDB contains most of the information pertaining to methodology and data accuracy. Electronic products contain a link to the IMDB, which is used to access documentation relevant to the product. As for hard copy

products, the IMDB ensures adequate documentation, in compliance with the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2).

- Consider the readership of each document. Subject the document to extensive review by managers, representatives of the intended readers and peers to ensure quality and readability (Statistics Canada, 1995). Edit documents meticulously. Date each version of the document. Check references.

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2.17 Administrative data use

Scope and purpose

Administrative records are data collected for the purpose of carrying out various non-statistical programs. For example, administrative records are maintained to regulate the flow of goods and people across borders, to respond to the legal requirements of registering particular events such as births and deaths, and to administer benefits such as pensions or obligations like taxation. As such, the records are collected with a specific decision-taking purpose in mind, and so the identity of the unit corresponding to a given record is crucial. In contrast, in the case of *statistical records*, on the basis of which no action concerning an individual is intended or even allowed, the identity of individuals is of no interest once the database has been finalized.

Administrative records present a number of advantages to a statistical agency and to analysts. Demands for statistics on all aspects of our lives, our society and our economy continue to grow. These demands often occur in a climate of tight budgetary constraints. Statistical agencies also share with many respondents a growing concern over the mounting burden of response to surveys. Respondents may also react negatively if they feel they have already provided similar information (e.g., revenue) to administrative programs and surveys. Administrative records, because they already exist, do not require the cost of direct data collection nor do they impose a further burden on respondents. It is important to note that the explosion of technology has also permitted statistical agencies to overcome the limitations caused by the processing of large datasets. For all these reasons, administrative records are becoming increasingly usable and are being used for statistical purposes.

Statistical uses of administrative records include (i) use for survey frames, directly as the frame or to supplement an existing frame, (ii) replacement of data collection (e.g., use of taxation data for small businesses in lieu of seeking survey data for them), (iii) use in editing and imputation, (iv) direct tabulation, (v) indirect use in estimation (e.g., as auxiliary information in calibration estimation, benchmarking or calendarisation), and (vi) survey evaluation, including *data confrontation* (e.g., comparison of survey estimates with estimates from a related administrative program).

Principles

It is Statistics Canada's policy to use administrative records whenever they present a cost-effective alternative to direct data collection. As with any data acquisition program, consideration of the use of administrative records for statistical purposes is a matter of balancing the costs and benefits. Administrative records start with a huge advantage they avoid further data collection costs and respondent burden, provided the coverage and the conceptual framework of the administrative data are compatible with the target population. Depending on the use, it is often valuable to combine an administrative source with another source of information.

The use of administrative records may raise concerns about the privacy of the information in the public domain. These concerns are even more important when the administrative records are linked to other sources of data. The Policy on Informing Survey Respondents (Statistics Canada, 1998a) requires that Statistics Canada provides all respondents with information such as the purpose of the survey, the confidentiality protection, the record linkage plans and the identity of the parties to any agreements to share the information provided by those respondents. Record linkage must be in compliance with the Agency's Policy on Record Linkage (Statistics Canada, 1996a). In particular, all requests for record linkage must be submitted to the Confidentiality and Legislation Committee and approved by the Policy Committee.

The use of administrative data may require the statistical agency to implement a number, usually only a few, of the survey steps discussed in previous sections. This is because many of the survey steps (e.g., direct collection and data capture) are performed by the administrative organization. As a result, additional guidelines to those previously presented are required to suggest ways to compensate for any differences in the quality goals of source organization (e.g., to compensate for the outgoing quality from the data capture, which is often uncontrolled).

One must keep in mind the fundamental reason for the existence of these administrative records: they are the result of an administrative program that was put in place for administrative reasons. Often the statistical uses of these records were unknown when the program was implemented and statistical agency invariably has limited impact in the development of the program. For that reason, any decisions related to the use of administrative records must be preceded by an assessment of such records in terms of their coverage, content, concepts and definitions, the quality assurance and control procedures put in place by the administrative program to ensure their quality, the frequency of the data, the timeliness in receiving the data by the statistical agency and the stability of the program over time. Obviously, the cost of obtaining the administrative records is also a key factor in the decision whether to use such records.

Guidelines

- Many of the guidelines in earlier sections are applicable to administrative records. Sampling and data capture guidelines (see Sections 2.4 and 2.7) will be relevant if administrative records exist only on paper and have to be coded and captured. These guidelines will also be of value for administrative data available in electronic form, including EDI and EDR. Note that these data, because they exist in electronic form, may be inherently less stable and subject to additional errors arising from data treatment and transmission processes at source. Editing and dissemination guidelines (see Sections 2.8 and 2.14) apply to all cases where a file of individual administrative records is obtained or created for subsequent processing and analysis.

- Consider privacy implications of the publication of information from administrative records. Although the Statistics Act provides Statistics Canada

with the authority to access administrative records for statistical purposes, this use may not have been foreseen by the original suppliers of information (Statistics Canada, 1970). Therefore, programs should be prepared to explain and justify the public value and innocuous nature of this secondary use.

- Collaborate with the designers of new or redesigned administrative systems. This can help in building statistical requirements into administrative systems from the start. Such opportunities are rare, but when they happen, the eventual statistical value of the statistical agency's participation can far exceed the time expended on exercise.

- Maintain continuing liaison with the provider of administrative records. Liaison with the provider is necessary at the beginning of the use of administrative records. However, it is even more important to keep in close contact with the supplier at all times so that the statistical agency is not surprised by any impeding changes, and can even influence them. Feedback to the supplier of statistical information and of weaknesses found in the data can be of value to the supplier, leading to a strengthening of the administrative source.

- Understand the context under which the administrative organization created the administrative program (e.g., legislation, objectives, and needs). It has a profound impact on (i) the universe covered, (ii) the contents, (iii) the concepts and definitions used, (iv) the frequency and timeliness, (v) the quality of the recorded information, and (vi) the stability over time.

- Study each data item in the administrative records that are planned to be used for statistical purposes. Investigate its quality. Understand the concepts, definitions and procedures underlying its collection and processing by the administrative organisation. Some of the items might be of very poor quality and thus might not be fit for use. For example, the quality of classification coding (e.g., occupation, industrial activity, geography) might not be sufficient for some statistical uses or might limit its use.

- Like data collected by means of a survey, administrative data are also subject to partial and total nonresponse. In some instances, the lack of timeliness in obtaining all administrative data introduces greater nonresponse. Some guidelines provided in section 2.6 will thus apply. Unless nonrespondents can be followed up and responses obtained, develop an imputation or a weight-adjustment procedure to deal with this nonresponse (see Sections 2.9 and 2.10). Administrative sources are sometimes outdated. Therefore, as part of the imputation process, give special attention to the identification of active and/or inactive units. Some imputation or transformation may also be required in cases where some of the units report the data at a different frequency (e.g., weekly or quarterly) than the one desired (e.g., monthly).

- Keep in mind that if the information they provide to the administrative source can cause gains or losses to individuals or businesses, there may be biases in the information supplied. Special studies may be needed in order to assess and understand these sources of error.

- Document the nature and quality of the administrative data once assessed. Documentation helps statisticians decide the uses to which the administrative data are best suited. Choose appropriate methodologies for the statistical program based on administrative data and inform users of the methodology and data quality.

- Keep in mind that the longevity of the source of administrative data and its continued scope is usually entirely in the hands of the administrative organization. The administrative considerations that originally dictated the concepts, definitions, coverage, frequency, timeliness and other attributes of the administrative program may, over time, undergo changes that distort time series derived from the administrative source. Be aware of such changes, and deal with their impact on the statistical program.

- Implement continuous or periodic assessment of incoming data quality. Assurance that data quality is being maintained is important because the statistical agency does not control the data collection process. This assessment may consist of implementing additional safeguards and controls (e.g., the use of statistical quality control methods and procedures, edit rules) when receiving the data, comparisons with other sources or sample follow-up studies.

- When record linkage of administrative records is necessary (e.g., for tracing respondents, for supplementing survey data, or for data analysis), conform to the Agency's Policy on Record Linkage. Privacy concerns that may arise when a single administrative record source is used are multiplied when linkage is made to other sources. In such cases, the subjects may not be aware that information supplied on two separate occasions is being combined. The Policy on Record Linkage is designed to ensure that the public value of each record linkage truly outweighs any intrusion on privacy that it represents.

- It is not always easy to combine an administrative source with another source of information. This is especially true when a common matching key for both sources is not available and record linkage techniques are used. In this case, select the type of linkage methodology (i.e., exact matching or statistical matching) in accordance with the objectives of the statistical program. When the purpose is frame creation and maintenance, edit and imputation or weighting, exact matching is appropriate. When the sources are linked for performing some data analyses that are impossible otherwise, consider statistical matching, i.e., matching of records with similar statistical properties (see Cox and Boruch, 1988; Scheuren and Winkler, 1993; Kovacevic, 1999).

- When record linkage is to be performed, make appropriate use of existing software. Statistics Canada's Generalized Record Linkage Software is but one example of a number of well-documented packages.

- When data from more than one administrative source are combined, pay additional attention to reconcile potential differences in their concepts, definitions, reference dates, coverage, and the data quality standards applied at each data source. Examples are education data sources, health and crime reports, and registries of births, marriages, licenses, and registered vehicles, which are provided by various organizations and government agencies.

- Some administrativeta aregitudinal in natureeg., incmex, goods and services). When records fromrent reference periods are linked, they are very rich data mines for researchers. Remain especiallygilant when creating such longitudinal and person-oriented databases, as their use raises very serious privacy concerns. Use the identifier with care, as a unit may change identifiers over time. Track down such changes to ensure proper temporalta analsis. In some instances the same unit ma have two or more identifiers for the same reference period, thus introducing duplication in the administrative file. If this occurs, develop an unduplication mechanism.

- Administrative information is sometimes used to replace a set of questions that would otherwise be asked of the respondent. In this instance, permission from the respondent may have to be obtained. Fllow the Policy on Informing Survey Respondents in this regard. When consent is not obtained, put collection procedures in place for the equivalent survey questions to be asked of the respondents.

- Administrative files are often very large and their use can sometimes lead to significant processing costs and timeliness issues. Depending on the need, make use of a random sample from large administrative files to reduce costs.

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3. The management context

This section outlines the management context within which these Quality Guidelines are applied. The Agency's management structure, policies and guidelines, consultative mechanisms, project development and management approach, and environment have been developed to facilitate and assure effective management of quality. The basic mechanisms for managing quality, as part of Statistics Canada's Quality Assurance Framework (Statistics Canada, 2002c), are summarized here in terms of the six elements of quality described in Section 1.

3.1 Quality at Statistics Canada

Statistics Canada's product is information. If its information becomes suspect, the credibility of the Agency would be called into question and its reputation as an independent, objective source of trustworthy information undermined. The management of quality must therefore play a central role in the overall management of the Agency and be an integral part of the management of every program.

A significant feature of the management of quality is the balancing of quality objectives against the constraints of financial and human resources, the goodwill of respondents in providing source data, and competing demands for greater quantities of information. The management of quality is not the maximization of quality at all costs, but the achievement of an appropriate balance between the quantity and quality of information yielded by the Agency's program and the resources available. Within individual programs the challenge is to make the appropriate trade-offs between the evolving needs of clients, costs, respondent burden, and the various elements or dimensions of quality.

Statistics Canada strives to build quality - *fitness for use* - into all its programs and products. The quality of its official statistics is founded on the use of sound scientific methods adapted over time to changing client needs, to the changing reality that the Agency aims to measure, and to the capacity or willingness of respondents to supply reliable and timely data. These Quality Guidelines are one of the tools that will aid in building quality into the design of each program.

3.2 Management framework

The management of quality at Statistics Canada occurs within a matrix management framework – project management operating within the functional organization. The Agency is functionally organized into seven Fields. Four of these are primarily responsible for statistical programs of data production and analysis in various subject-matter areas. The other three Fields are primarily involved in the provision of infrastructure and services to be used by the statistical programs. The typical statistical program is managed by one of the subject-matter divisions and draws heavily on the resources of service areas for inputs to their programs, particularly for collection and processing operations, for informatics support, for statistical methodology, and for marketing and dissemination support.

The use of an interdisciplinary project team approach for the design or redesign of a statistical program is important in ensuring that quality considerations relating to all the components and steps in the program receive appropriate attention during design, implementation and assessment. It is the responsibility of the functional organizations to ensure that project teams are adequately staffed with people able to speak with expertise and authority for their functional area. Subject-matter staff bring knowledge of content, client needs, and relevance. Methodologists bring their expertise in statistical methods and data quality trade-offs, especially with respect to accuracy, timeliness and cost. Operations experts bring experience in operational methods, and concerns for practicality, efficiency, field staff and respondents. The system experts bring a systems view, and knowledge of technology standards and tools to the design.

It is within such a project team that the many decisions and trade-offs necessary to ensure an appropriate balance between concern for quality and considerations of cost and response burden are made. Together the team has to balance the conflicting pressures in order to develop an optimal design. The fact that each member of the team is a part of a specialized functional organization, from which a variety of more specialized and management resources can be called upon when warranted, helps in resolving both technical challenges and conflicts arising in a project.

Projects are normally guided by a more senior Steering Committee that may include managers from each of the major participating areas. This Committee, which is part of the formal approval mechanism for the design and implementation of the program, provides overall guidance, broad budgetary and design parameters, and helps to ensure that appropriate resources are available to the project. It also provides a forum for resolving any issues that cannot be satisfactorily resolved within the project team.

This management framework is a systemic and important component of Statistics Canada's Quality Assurance Framework.

3.3 The Quality Assurance Framework

The *Quality Assurance Framework* is the set of management, operating and consultative practices, procedures, and mechanisms that are used by Statistics Canada to manage the quality of its information products. This framework has been developed and adapted over a period of many years, and continues to evolve. It links user needs with program products and provides for feedback, performance review, and ongoing planning and development. It gives direction and guidance to project and program managers and in turn, to their teams, to achieve overall coherence and balance within programs among what may be conflicting priorities, constraints, and design and quality issues. The Quality Assurance Framework is summarized below in the context of the six elements of quality – relevance, accuracy, timeliness, accessibility, interpretability and coherence - with a brief discussion of key supports to quality under the topic of the Environment of the Agency.

3.3.1 Managing relevance

The management of relevance embraces those processes that lead to the determination of what information the Agency produces and the level of resources to be devoted to each program. It deals essentially with the translation of user needs into program approval and budgetary decisions within the Agency. The processes that are used to assure relevance also permit basic monitoring of other elements of quality and correspondingly to assess user requirements in these other dimensions.

To fulfill its mandate it is paramount that the Agency's programs and outputs properly and continuously reflect the country's most important information needs. Since these needs evolve over time, a process for continuously reviewing programs in the light of client needs and making necessary adjustments is essential.

User needs are identified through bilateral and multilateral liaison with major users, through information and advice provided by statistical organizations and consultative groups and through user feedback on existing products and services. Regular reviews of all programs are conducted through biennial and quadrennial program reports, as well as through ad hoc reviews or audits.

Data analysis also provides feedback on information gaps and limitations: directly from analysts; through published articles and through the peer review processes for these articles and through feedback in reaction to and commentary on analytical results; and through the use of analytical frameworks such as the System of National Accounts, that integrate and reconcile data from different sources within Statistics Canada.

Program decisions and adjustments usually take place through an annual strategic and long-term planning process that examines new and developing information needs. In addition to user needs and costs, respondent burden, public sensitivities, and the Agency's capacity and expertise have to be taken into account. Judgements have to be made in light of current public policy priorities as to which statistical programs are in most need of redevelopment or of new or additional investment.

There are, however, constraints on change or adjustment. It has been estimated that more than 90% of the Agency's budgetary resources are devoted to ongoing programs that are non-discretionary at a given point in time. These programs serve the information needs of a broad clientele through provision of basic information on Canadian society and the Canadian economy, and they meet the legislative and regulatory needs specified in approximately two dozen Acts of Parliament.

A second constraint on adjustment is the interdependency between different programs. In many cases information from one program feeds another (e.g., retail sales information feeds into GDP calculations, vital statistics are used in population estimates) so that the impact of adjustments in one program on other programs has to be considered.

New or emerging information needs must therefore be funded through savings within non-discretionary programs that do not imperil their outputs, through redirection of resources within the discretionary component, or through persuading clients (particularly federal government clients) to finance such worthy additions to the national database.

3.3.2 Managing accuracy

Processes described under relevance determine which programs are going to be carried out, their broad objectives, and the resource parameters within which they must operate. Within those "program parameters" the management of accuracy requires particular attention during the design and implementation, and assessment phases of a statistical activity, each one built on the others.

3.3.2.1 Program design and implementation

The accuracy achieved through program design - as well as the degree of timeliness and coherence - will depend on the explicit methods put in place and the quality assurance processes built in to identify and control potential errors at the various stages of implementation of the program. Decisions on what constitutes acceptable accuracy are left to the individual program to determine and justify in light of its knowledge of user requirements and the circumstances, budget and other constraints, opportunities and objectives within which it has to work.

These Quality Guidelines describe specific practices, methods and considerations that should be taken into account in designing programs, and indicate where formal standards or guidelines exist. While the strength of the survey methodology will depend on the judgements of the survey design team, whatever specific methods are applied must be within the realm of commonly accepted and defendable statistical practices under the given circumstances. The use of new technologies and innovations to improve quality and efficiency is encouraged, but must be adequately tested to minimize risk. It must be possible to monitor quality, to react effectively to unanticipated problems and to be able to verify or support the credibility of the results, as well as to understand their limitations.

The results of implementation depend not only on the specific design and the survey instruments (e.g., the sample design and the questionnaire), but also on the instruments of implementation. These latter instruments will include the resource and material plans, the supervisory structure, the schedules, the operations, procedures and checks, the training, the publicity, etc., developed and specified during the design phase. Mechanisms for monitoring implementation should be built into survey processes as part of design. Two types of information are required. The first is information to monitor and correct, in real time, any problems arising during implementation. The second is information to assess, after the event, whether the design was carried out as planned, whether some aspects of the design were problematic in operation, and what lessons were learned from the operational standpoint to aid future designs. Information pertaining directly to accuracy as well as information related to costs and efficiency of operations is equally important to the consideration of accuracy for future designs.

3.3.2.2 Accuracy assessment

The assessment of accuracy entails determining what level of accuracy has actually been achieved. It needs to be a consideration at the design stage since the measurement of accuracy often requires information to be recorded as the survey is taking place.

As with design, the extent and sophistication of accuracy assessment measures will depend on the size of the program, and on the significance of the uses of the estimates. Statistics Canada's Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2) requires at least the following four primary areas of accuracy assessment to be considered in all programs: assessment of the coverage of the survey; assessment of sampling error where sampling was used (standard errors, or coefficients of variation, should be provided for key estimates); nonresponse rates and estimates of the impact of imputation; and descriptions or measures of other serious accuracy or consistency problems with the survey results. Measures of accuracy are also an important input for Program Review for assessing whether user requirements are being met, and for allowing appropriate analytic use of the data. They are also a crucial input to the management of interpretability as elaborated below.

In light of the high technical content of many design issues, programs are encouraged to incorporate independent technical reviews into their design, implementation and accuracy assessment plans. This may be done, for example, through an internal technical review committee for major programs; referral of issues of technical standards, or general methods or approaches to the Methods and Standards Committee; or an Advisory Committee.

3.3.3 Managing timeliness

Timeliness of information refers to the length of time between the reference point, or the end of the reference period, to which the information relates, and its availability to users. Information that is available to users well within the period during which it remains useful for its main purposes is considered to be timely.

Planned timeliness is a design decision, often based on trade-offs with accuracy and cost. Improved timeliness is not, therefore, an unconditional objective. However, timeliness is an important characteristic that should be monitored over time to warn of deterioration, and across programs, to recognize extremes of tardiness, and to identify good practices. Major information releases should have release dates announced well in advance. The achievement of planned release dates also should be monitored as a timeliness performance measure, as should changes in planned release dates, over longer periods.

For some programs, the release of preliminary data followed by revised and final figures is used as a strategy for making data timelier. In such cases, the tracking of the size and direction of revisions can serve to assess the appropriateness of the chosen timeliness-accuracy trade-off. It also provides a basis for recognizing any persistent or predictable biases in preliminary data that could be removed through estimation.

For ad hoc surveys and new surveys, and for programs that offer customized data retrieval services, the appropriate timeliness measure is the elapsed time between the receipt of a clear request and the delivery of the information to the client. Service standards should be in place for such services, and their achievement monitored.

Improvements in timeliness might be expected as new technologies are developed and as uses of data change. There may be an ongoing need to assess current practices to achieve and improve timeliness through operational evaluations, experimentation, testing and process measurement. The ability to inform users on timeliness constraints is also an important aspect of the management of timeliness.

3.3.4 Managing accessibility

Accessibility of information refers to the ease with which users can learn of its existence, locate it, and import it into their own working environment. Statistics Canada's dissemination objective is to maximize the use of the information it produces while ensuring that dissemination costs do not reduce the Agency's ability to collect and process data in the first place. Corporate-wide dissemination policies and delivery systems determine most aspects of accessibility.

Program managers are responsible for designing statistical products, choosing the appropriate delivery systems and ensuring that statistical products are properly included within corporate catalogue systems. In determining what information products and services to offer, program managers must liaise with clients, research and take careful account of client demands and monitor client feedback on the content and medium of their products. (The Agency's Marketing Division provides services to assist in or facilitate these processes.) Program managers must also ensure that products comply with the policies and standards requirements in Highlights of Publications, Informing Users of Data Quality and Methodology, Presentation of Data, and Review of Information Products (Statistics Canada, 2003d).

At the corporate level, the primary dissemination vehicles include: The Daily for the initial release of all data; CANSIM II as the repository of all publicly available data; the Statistics Canada website as a primary entry point for those seeking data; and an extensive program of publications and analytical reports for specific client groups.

Advisory Services provides a single point of access to Statistics Canada information and services through a network of Regional Reference Centres across the country. The Government's depository libraries program ensures that all our products are available to libraries across the country. The Agency's Data Liberation Initiative makes sure that universities have access to an array of Agency products for educational and research purposes at a reasonable cost.

A variety of options are open to program managers to make their data files more accessible for analytical purposes, including: the production of public-use microdata files that have been screened (and approved by the Microdata Release Committee) to protect

confidentiality; the provision of a custom retrieval service; contracting with an external analyst under the Statistics Act; and referral to the Research Data Centres program administered by the Social Sciences and Humanities Research Council of Canada.

3.3.5. Managing interpretability

Providing sufficient information to allow users to properly interpret statistical information is a responsibility of the Agency. Managing interpretability is primarily concerned with the provision of metadata or 'information about information'.

The information needed to understand statistical data falls under three broad headings:
a) the concepts, variables and classifications that underlie the data;
b) the methodology used to collect and compile the data; and
c) indicators of the accuracy of the data.

In the case of public-use micro-data files, information regarding the record layout and the coding/classification system used to code the data on the file is an essential tool to allow users to understand and use the data files.

Statistics Canada's standards and guidelines for the provision of metadata derive from the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000d; see Appendix 2). Program managers are responsible for ensuring that their products meet the requirements of this policy and for documenting their programs within the Integrated Metadatabase (Statistics Canada, 2000c).

A further aid to Statistics Canada's clients is interpretation of data as they are released through commentary in The Daily and through the highlighting of the principal findings in all statistical publications as required by the Policy on Highlights of Publications (Statistics Canada, 1985b). Serious public misinterpretations of data are responded to by policy (Statistics Canada, 1986b).

3.3.6. Managing coherence

Coherence of statistical data includes coherence between different data items pertaining to the same point in time, coherence between the same data items for different points in time, and international coherence. Three complementary approaches are used for managing coherence in Statistics Canada.

The first approach is the development and use of standard frameworks (e.g., the System of National Accounts), concepts, variables and standard classification systems for all major variables as well as consideration of international standards where these exist.

The second approach aims to ensure that the process of measurement does not introduce inconsistency between data sources even when the quantities being measured are defined in a consistent way: e.g., through the use of a common business register as the frame for all business surveys; the use of commonly formulated questions; the application of

"harmonized" methodologies and systems; the use of the Quality Guidelines; the use of established centres of expertise in certain methodologies and technologies; reference to international codes of best practice.

The third approach analyses the data themselves and focuses on the comparison and integration of data from different sources or over time (e.g., the integration of data in the national accounts, benchmarking or calibration of sub-annual and annual estimates). This kind of analysis attempts to recognize situations where variation or inconsistency exceeds levels implied by the expected accuracy of the data. Feedback from external users and analysts of data that point out coherence problems with current data is also an important component of coherence analysis.

3.3.7 Environment

The management of the six dimensions of quality, of course, takes place in an organizational environment. In place are measures that aim to create an environment and culture that recognizes the importance of quality to the Agency's effectiveness and that promotes quality.

The measures include a program of entry-level recruitment and development for major occupational groups, and an overall training and development framework. They include a variety of communication vehicles to provide employees with information and to seek employee feedback on how to improve programs and the organizational environment. They include explicit measures to develop partnerships and understandings with the Agency's suppliers. Particular attention is paid in following-up on respondent complaints. Questionnaires are tested to ensure minimal intrusion on privacy, to respect public sensitivities and to gain overall social acceptability. Cooperative arrangements with data respondents are pursued through a number of means including a respondent relations program and a response burden management program.

They also include programs of data analysis and methodological research that encourage a continuous search for improvement. Conducting data analysis promotes the relevance, accuracy and coherence of the Agency's statistical data while allowing staff to obtain broader contacts and experience. Similarly, research and development of methods and tools of a statistical, subject matter, informatics or operational nature helps to achieve high quality and to create a culture of quality improvement, in addition to yielding efficiency gains.

3.4 Conclusion

Statistics Canada's quality assurance framework consists of a wide variety of mechanisms and processes acting at various levels throughout the Agency's programs and across its organization. The effectiveness of this framework depends not on any one mechanism or process but on the collective effect of many interdependent measures. These build on the professional interests and motivation of the staff. They reinforce each other as means to serve client needs. They emphasize the Agency's objective

professionalism, and reflect a concern for data quality. An important feature of this strategy is the synergy resulting from the many players in the Agency's programs operating within a framework of coherent processes and consistent messages.

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4. List of acronyms

ACTR	Automated Coding by Text Recognition
CANCEIS	Canadian Census Edit and Imputation System
CANSIM	Canadian Socio-economic Information Management System
CV	Coefficient of Variation
DC2	Generalized Data Collection and Data Capture System
EDI	Electronic Data Interchange
EDR	Electronic Data Reporting
CAPI	Computer-Assisted Personal Interviewing
CATI	Computer-Assisted Telephone interviewing
GArDS	Generalized Area Delineation System
GEIS	Generalized Edit and Imputation System
GES	Generalized Estimation System
GREG	Generalized Regression Estimator
GSAM	Generalized Sampling System
ICR	Intelligent Character Recognition
IMDB	Integrated Metadatabase
QCDAS	Quality Control Data Analysis System
RDD	Random Digit Dialling
STC	Statistics Canada
TQM	Total Quality Management

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6. Appendices

6.1. Appendix 1: Policy on the Review and Testing of Questionnaires

Revised September 25, 2002

Background

Questionnaires play a central role in the data collection process. They have a major impact on data quality, particularly response accuracy, and on the image that Statistics Canada projects to the public. These impacts are especially critical for on-going and longitudinal survey programs.

A well-designed questionnaire should minimize the response burden for respondents and collect data efficiently with a minimum number of response and nonresponse errors. Moreover, well-designed questionnaires should facilitate the coding and capture of data. They should minimize the amount of edit and imputation that is required, and lead to an overall reduction in the cost and time associated with data collection and processing.

Statistics Canada aims to ensure that questionnaires collect accurate information and that they are adequately tested, easy to administer, easy to process, respondent-friendly and interviewer-friendly. The review and testing of questionnaires are instrumental in identifying potential sources of response and nonresponse errors. This policy, therefore, establishes the requirement for the review and testing of new and revised questionnaires. It also establishes the requirement for the periodic review of questionnaires used in on-going and longitudinal surveys. The policy concerns all aspects of questionnaire design that may influence data quality, respondent behaviour and interviewer performance. This Policy also supports the use of standard formulations of commonly asked questions across surveys, where appropriate, as a means of using well-tested questions and promoting coherence.

Definition

For the purposes of this policy, a questionnaire is defined as a set of questions that is designed to collect information from a respondent. A questionnaire may be interviewer-administered or respondent-completed.

Scope

The scope of the policy covers all questionnaires administered by Statistics Canada to external respondents. It includes questionnaires used in statistical and information collection programs as well as in other programs such as market research and program evaluation. The scope covers both paper-and-pencil methods of data collection and non-paper modes such as computer-assisted interviewing and Internet-based data collection. The policy also includes revisions to a questionnaire that result from a change in the data

collection method (for example, from paper-and-pencil to computer-assisted interviewing or Internet-based data collection).

Policy Statement

It is the policy of Statistics Canada that:

1. All new questionnaires and revisions to existing questionnaires shall undergo testing in both official languages before implementation.

2. Program areas shall consult with the Questionnaire Design Resource Centre regarding plans for testing new or revised questionnaires. The attached guidelines provide an overview of the testing methods that can be used.

3. All new and revised questionnaires shall be reviewed by the Questionnaire Design Resource Centre before testing takes place and again after revisions have been made as a result of testing.

4. All questionnaires used in on-going and longitudinal surveys should be reviewed periodically.

Responsibilities

1. Program Areas

- Ensure that all requirements for implementing this policy are in place. This includes making adequate budget provisions and scheduling sufficient time for the review and testing of new or redesigned questionnaires.

- Consult with the Questionnaire Design Resource Centre regarding plans for testing new or revised questionnaires.

- Submit every new or revised questionnaire to the Questionnaire Design Resource Centre for review before testing takes place and again after revisions have been made as a result of testing.

- Consult with the Standards Division to ensure compliance with standards and the use of common forms of question where these exist; consult as appropriate with the Communications Division regarding respondent relations and with the Dissemination Division regarding forms design and production.

- Submit every new or revised questionnaire to the Data Access and Control Services Division.

- Submit the final version of every new or revised questionnaire to the Standards Division for inclusion in the "Index to Statistics Canada Surveys and Questionnaires."

2. Data Access and Control Services Division

- Ensures that questionnaires conform with the Policy on Informing Survey Respondents.
- Alerts program areas to the requirements of this policy when necessary.
- Ensures that the Chief Statistician's authorization for the information collection to take place is obtained.

3. Questionnaire Design Resource Centre (Methodology Branch)

- Offers a review and consulting service on questionnaire design.
- Provides assistance and guidance in the development and testing of new and revised questionnaires. This includes: (a) testing questionnaires using methods such as focus groups, in-depth interviews, cognitive interviews and informal testing and (b) coordinating development and testing activities that are contracted out.
- Reviews questionnaires with attention to the wording and sequencing of questions, length, format, respondent-friendliness and interviewer-friendliness.
- Provides documentation, guidelines and training to improve questionnaire design.

4. Dissemination Division

- Provides assistance in the design, format, composition and printing aspects of survey questionnaires and forms.
- Ensures that the questionnaire meets the requirements of the Federal Identity Program.

5. Methods and Standards Committee

- Monitors the implementation of this policy.
- Approves any guidelines on questionnaire design that are issued under this policy.
- Promotes the use of common question formulations across surveys where appropriate.

6.2. Appendix 2: 2.3 Policy on Informing Users of Data Quality and Methodology

Approved March 31, 2000

Introduction

Statistics Canada, as a professional agency in charge of producing official statistics, has the responsibility to inform users of the concepts and methodology used in collecting, processing and analysing its data, of the accuracy of these data, and of any other features that affect their quality or "fitness for use".

Data users first must be able to verify that the conceptual framework and definitions that would satisfy their particular data needs are the same as, or sufficiently close to those employed in collecting and processing the data. Users then need to be able to assess the degree to which the accuracy of the data and other quality factors are consistent with their intended use or interpretation.

There are several dimensions to the concept of quality, and the assessment of data quality or "fitness for use" is a complex undertaking. The full scope of potential uses of the data cannot always be anticipated and not every aspect of quality can be assessed in every context. In particular, data are subject to many potential sources of error and, under the present state of knowledge, comprehensive measurement of data accuracy is rarely possible. Thus there are clear limitations to the provision of measures of accuracy to users, and a rigid requirement for comprehensive measurement and assessment of data quality for all Bureau products would not be achievable. Rather, emphasis must be placed on describing and quantifying the major quality features of the data.

Policy

1. Statistics Canada will make available to users indicators of the quality of data it disseminates and descriptions of the underlying concepts and methodology.

2. Statistical products will be accompanied by or make explicit reference to documentation on quality and methodology.

3. Documentation on quality and methodology will conform to such standards and guidelines as shall from time to time be issued under this Policy.

4. Exemption from the requirements of this policy may be sought in special circumstances using the procedure described below under "Responsibilities".

5. Sponsors of cost recovery surveys and statistical consultation work, for which no data will be disseminated by Statistics Canada, are to be made aware of and encouraged to conform to the applicable elements of the standards and guidelines issued under this Policy.

Scope

This policy applies to all statistical data and analytical results disseminated by Statistics Canada however collected, derived or assembled, and irrespective of the medium of dissemination or the source of funding.

Responsibilities

Directors of Program Areas will be responsible for:

- informing users of the availability of information on data quality and methodology;
- dissemination of existing measures or descriptions of data quality and documentation on methodology;
- ensuring that procedures to generate the information on data quality needed to satisfy this Policy have been, or are, developed and implemented;
- the preparation of documentation on methodology needed to satisfy this Policy;
- the inclusion of requirements to satisfy this Policy in the design, schedule and budget of new or re-designed statistical activities, programs or products; and
- the submission to the Methods and Standards Committee of applications for exemption from the requirements of this policy.

The Methods and Standards Committee will be responsible for:

- the production of periodic reports on the state of compliance with this policy;
- the initiation of periodic evaluations of the application of this policy within particular Program Areas and ensuring that such evaluations are co-ordinated with program evaluation exercises;
- the provision of standards and guidelines on the application of the policy to Program Areas;
- the initiation of a review of the policy and accompanying standards and guidelines when deemed necessary; and
- the review and approval of applications for exemption from the policy requirements.

Inquiries

Inquiries relating to the interpretation of this policy should be addressed to the Chairperson of the Methods and Standards Committee.