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Statistics Canada Quality Guidelines

Third Edition - October 1998

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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 and governments. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

PREFACE

In some professions best practice is codified precisely or defined by reference to professional codes and standards. No such precise code exists in the domain of survey methodology. Indeed, survey methodology is a collection of practices, backed by some theory and empirical evaluation, among which practitioners have to make sensible choices in the context of a particular application. These choices must attempt to balance the often competing objectives of quality, relevance, timeliness, cost, and reporting burden.

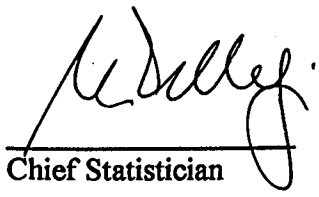
The present document consolidates a set of experiences and conclusions, each of which was assessed in its particular context to represent "good practice." They do not apply in their totality to any particular data acquisition process. Furthermore, even if a specific guideline were theoretically applicable to a given survey, the particular circumstances might be such that good professional judgement would give relatively little weight, and hence only passing consideration, to that guideline as opposed to others which in the given context might be considerably more important. This document must therefore be used with great 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. There have been significant developments since that time in survey methodology, for example in the integration of computer technology and electronic communications into data collection and processing. This has led to changes in the flow of survey operations as well as to new approaches to the storage and dissemination of data. Motivated by advances in survey methodology such as this, the present document has been significantly updated from the earlier edition.

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

Ivan P. Fellegi



Chief Statistician

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1. INTRODUCTION

This document brings together guidelines and checklists of issues to be considered in the pursuit of quality objectives in the execution of statistical activities. It draws on the collective experience of many Statistics Canada employees. It should be useful to staff engaged in the planning and design of surveys as well as those who evaluate and analyze the results.

Since the publication of the earlier versions of Quality Guidelines, the use of the term *quality* has broadened, largely because of the *Total Quality Management* (TQM) movement. We retain the term "quality" to signify the fitness for use of statistical data. It encompasses not only the statistical quality concepts of variance and bias, but also relevance in the sense of measuring the right things and of being available in time to be useful.

While broad, this definition is narrower than that of quality in the TQM sense. To reconcile the two, it is worth considering what TQM means for a statistical agency. To oversimplify, there seem to be three elements that comprise TQM: knowing and understanding the clients' (i.e., users') needs; involving employees in decision-making associated with meeting these needs; and continuously reviewing business processes for reengineering potential. That attention to these three activities will lead to quality improvement is as true for a statistical agency as it is for any other organization. These Quality Guidelines are related to all three of these elements and support Statistics Canada's long-standing efforts to ensure the quality of its products and services. The following paragraphs expand on the various dimensions of quality with which a statistical agency needs to be concerned (Statistics Canada, 1997a).

The quality of data must be defined and assured in the context of being "fit for use." Whether data and statistical information are fit for use will depend on the intended uses and on their fundamental characteristics of quality, as well as on the expectations of users for what is acceptable for these characteristics of quality.

Among statistical agencies there is no standard definition of quality for official statistics. There is, nevertheless, a generally accepted but evolving range of quality issues underlying "fitness for use." The particular issues of quality or fitness for use that must be addressed by Statistics Canada can be summarized as relevance, accuracy, timeliness, accessibility, interpretability and coherence. These *elements of quality* need to be considered and balanced in the design and implementation of the agency's statistical programs.

The *relevance* of data or of statistical information is a qualitative assessment of the value contributed by these data. Value is characterized by the degree to which the data or information serve to address the purposes for which they are produced and sought by users. Value is further characterized by the merit of those purposes, in terms of the mandate of the agency, legislated requirements and the opportunity cost to produce the data or information.

Accuracy of data or statistical information is the degree to which those data correctly estimate

or describe the quantities or characteristics that the statistical activity was designed to measure. Accuracy has many attributes, and in practical terms there is no single aggregate or overall measure of it. Of necessity these attributes are typically measured or described in terms of the error, or the potential significance of error, introduced through individual major sources of error - e.g., coverage, sampling, nonresponse, response, processing and dissemination.

Timeliness of information reflects the length of time between its availability and the event or phenomenon it describes, but considered in the context of the time period that permits the information to be of value and still acted upon. It is typically involved in a trade-off with reliability.

Accessibility reflects the availability of information from the holdings of the agency, also taking into account the suitability of the form in which the information is available, the media of dissemination, the availability of meta-data, and whether the user has reasonable opportunity to know it is available and how to access it. The affordability of that information to users in relation to its value to them is also an aspect of this characteristic.

Interpretability of data and information reflects the ease with which the user may understand and properly use and analyze the data or information. The adequacy of the definitions of concepts, target populations, variables and terminology underlying the data, and information on any limitations of the data largely determines their degree of interpretability.

Coherence of data and information reflects the degree to which the data and information from a single statistical program, and data brought together across data sets or statistical programs, are logically connected and complete. Fully coherent data are logically consistent - internally, over time, and across products and programs. Where applicable, the concepts and target populations used or presented are logically distinguishable from similar, but not identical, concepts and target populations of other statistical programs, or from commonly used notions or terminology.

These elements of quality are overlapping and interrelated, often in a perverse and confounding manner. Just as there is no single measure of accuracy, there is no effective statistical model for bringing together all these characteristics of quality into a single indicator. There is not a general statistical model for determining, except in simple or one dimensional cases, whether one particular set of quality characteristics provides higher overall quality than another.

Achieving an acceptable level of quality is the result of addressing, managing and balancing over time the various factors or elements that constitute quality, with due attention to the program objectives, the major uses of the data, costs, and the conditions and circumstances that affect quality and user expectations. Because the elements of quality have a complex relationship, an action taken to address or modify one aspect of quality will tend to affect

other elements of quality. Thus the balance of these factors may be altered in ways that cannot readily be modelled or adequately quantified in advance. The decisions and actions that achieve this balance are based on knowledge, experience, reviews, feedback and consultation, and inevitably on judgement.

The core of this document (Section 2) concentrates on *quality* issues as they relate to the *design* of individual *surveys* (as defined in Section 2). It is, however, important to keep in mind that the context in which each individual survey is being 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 going 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 magnified 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 cast 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 other roles are needed too, for example, that of a public relations specialist.

Section 3 outlines the management context within which these Quality Guidelines are applied. Referred to as 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 in 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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Statistics Canada (1997a). An Outline of Statistics Canada's Quality Assurance Framework. Unpublished report, Methods and Standards Committee, Statistics Canada.

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 by describing the *Scope and Purpose*, *Principles* and *Guidelines* as defined below. The first subsection addresses the stage at which objectives, uses and users (2.1) are identified. Ensuing subsections 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 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 proceed concurrently, for example, questionnaire design (2.5), frame development (2.3), and sampling plans (2.4). Still other steps, such as documentation (2.16) and data quality evaluation (2.12), touch on most other activities and do not take place as discrete activities on their own. Finally, administrative data use (2.17) is separately discussed to address issues specific to this type of data source.

Survey

We use the term *survey* 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 files originally collected for nonstatistical 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, 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

We use the term *design* to cover the definition 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).

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 separately documented 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 processes 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 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* describe the decisions to 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. Forming 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 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 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 data to meet the requirements of clients and the cost and time required to undertake a new activity involving the production of 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 as part of marketing 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, routinely conduct extensive and focused user consultation so as to identify content options and also to develop public support for the program when it reaches the data collection stage. Since relevant and accurate statistics are not useful if they are not trusted, taking a very open approach when developing or revising programs is important.

- 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. 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 details, 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 demands of the users they serve. 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, which may be evolving or changing. 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 response rates, sampling error, coverage rates, and timeliness. With administrative data and derived statistical activities, quality of output will be directly related to the quality of inputs.

- 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, Definitions and Classifications

Scope and Purpose

Concepts are the subjects of inquiry and analysis of interest to users. They refer to general characteristics or attributes of a statistical unit or of a population of like statistical units. *Definitions* describe not only the concepts in specific terms but also the variables used to measure the concepts. It is important that the definitions of the specific variables required for the measurement of the concepts be unambiguous and be clearly specified in the context of the analytical purposes for which the data are to be collected. Since all 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 and definitions underlying the data, i.e., what the data purport to measure. Although the use of harmonized concepts, definitions and classifications will assist users in comparing and integrating data, those put in place may have to differ in order to meet the intended need. The concepts, definitions 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 definitions and classifications chosen may need to take into account other factors as well, 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 definition 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 definitions clearly and relate them to their intended use. Make use of the Statistics Canada Policy on Standards (Statistics Canada, 1998c). In choosing naming conventions, take into account the similarity or dissimilarity with 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. 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.

- The use of standard definitions and classifications makes it possible to compare data collected from different sources and to integrate data across sources (Statistics Canada, 1998c). Statistics Canada has standard classifications of industries, products, occupations and geography (Statistics Canada, 1980, 1986a, 1992d, 1993d, 1993e). Policies relating to these standard classifications have been issued for the collection and dissemination of data (Statistics Canada, 1987b, 1994b, 1997c). Starting with the reference year 1997, the North American Industry Classification System (Statistics Canada, 1998a) is gradually replacing the 1980 Standard Industrial Classification and the Canadian Standard Industrial Classification for Companies and Enterprises 1980 as the industrial classification standard in the statistical programs of Statistics Canada.

- Statistics Canada's social statistics harmonization initiative outlines concepts, definitions of variables, possible classifications and indications of concordance with international practices for a variety of subject areas (Statistics Canada, 1997d). The status of each variable as a recommended best practice, as a recommended standard or as a standard is provided as well. This initiative emphasizes the use of standard definitions and classifications but allows for some freedom for users to pose their questions according to the constraints of the Policy on Standards and of their methodology and collection vehicle as long as the outputs map to the standards.

- 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. Since survey managers are often required to provide data to international agencies, converted to the international classifications, Standards Division has produced official concordances to the International Standard Industrial Classification of all economic activities (ISIC Rev2 and 3) and to the industrial classification used by Eurostat (NACE Rev 1) and a concordance to the International Standard Occupational Classification (ISCO) to assist survey divisions to convert data in a uniform way (U.S. Executive Office of the President et al., 1997). Concordances between different vintages of the national classifications also exist to assist survey managers and analysts to integrate data series.

- The use of standard units of observation also facilitates the comparison of data. In addition, classifications are usually designed with particular units of observation in

mind. For example, for production statistics, the standard industrial classification is based on the units of observation being the establishment and the location; for financial statistics, it is based on the company and the enterprise as units of observation.

- Derived statistical activities or statistical frameworks (e.g., the System of National Accounts) define a set of concepts and definitions that may have a significant effect on specific data collection activities (Statistics Canada, 1989).

- In the absence of an official standard, it is useful to examine the concepts, definitions and classifications being used by related statistical programs.

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2.3 Coverage and Frames

Scope and Purpose

A *frame* is any list, material or device that delimits, identifies, and allows access to the elements of the target population. The *target population* is the set of elements about which information is wanted and estimates are required, although practical considerations may dictate that some units be excluded (e.g., institutionalized individuals, the homeless). The extent to which a frame includes all the elements of the target population is referred to as *coverage*. Frames are generally of two types: area frames and list frames.

This section addresses the selection of a frame and the monitoring and maintenance of the quality of its coverage and related characteristics.

Principles

The survey frame should conform with the target population and contain minimal undercoverage and overcoverage (including duplication). Frame creation, use, maintenance and monitoring should be implemented within operational and cost constraints.

Characteristics of the frame units (e.g., classification, contact, address, size) should be of high quality because of their use in stratification, collection, follow-up, 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, or their use is prohibitively expensive, consider use of multiple frames (Hartley, 1962; Sirken and Casady, 1988).

- 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 and telephone files are options to consider.

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

- 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. Several techniques exist for this purpose: matching the frame or a sample of the frame with comparable alternative sources for the target 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; 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 lists from 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; and using evaluative information obtained from other surveys with the same frame (Lessler and Kalsbeek, 1992).

- In some cases, monitoring of the frame between the time of sample selection and the survey reference period may be desirable.

- Incorporate frame updates in the most timely manner possible.

- Effective training of staff, an emphasis on the importance of coverage, and the implementation of effective quality assurance procedures on frame-related activities will help minimize frame errors.

- 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).

- 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 through contact with the source manager. Where influence on the frame is possible, negotiate required changes with the source manager.

- Adjustments to the data or the use of supplementary data from other sources may be needed to offset coverage differences between the frame and the target population.

- Include descriptions of the target population, frame and coverage 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 target 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 of the information to be produced, the availability of appropriate sampling frames, the availability of suitable stratification variables, the estimation methods that will be used and the available budgets.

Principles

Probability sampling is used to select a representative sample of the target population. The intention is to gather useful information from the sampled units to allow inferences about the target population. Probability sampling implies a probabilistic selection from the frame in such a way that all target population units have known and positive *inclusion probabilities*. Sample size is determined in relation to the required precision and available budget for observing the selected units. The probability distribution that governs the sample selection is called a *sampling 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 get lowest possible cost for a fixed precision. Information collected for sampled units may be supplemented, at the estimation stage, with information (called *auxiliary information*) from other sources than the survey itself, such as administrative records and census projections. The choice of sampling design will take into account the availability of auxiliary information. These concepts are discussed in Särndal, Swensson and Wretman (1992).

Guidelines

- *Stratification* consists of dividing the population into subsets (called strata) before the selection of a sample within each of these subsets. From a practical point of view these subsets may be defined by the goals of the survey, for example, when provincial estimates are needed. From the statistical efficiency point of view, perform stratification in such a way that each stratum contains units that are relatively homogeneous with respect to the information requested in the survey.

- Sometimes the information needed to stratify is not available from the frame. When this is the case, a first large sample might be selected to get the required stratification information. This first sample is then stratified, and a subsample is selected within each stratum. This sampling design is called *two-phase sampling*. For this type of design, it is important to 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, it sometimes happens that it is difficult to select, or inconvenient to contact directly, the units that will report the requested information. Such cases require selecting first units (called *primary sampling units*) that are *clusters* of reporting units, and then subsampling within each of the selected primary sampling units to get a sample of the reporting units. Such sampling is called *two-stage sampling*. Budgetary or other constraints may require more than two stages. It is important to 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 ease of contact and of data collection/measurement, the quality of the data provided by the unit, and the cost of collecting data about and from that type of unit.

- 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, as well as both sampling factors (e.g., clustering) and non-sampling factors (e.g., nonresponse). For periodic surveys, consider that there will be births and deaths of units within the changing target 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 for other important variables. This problem is usually handled by first identifying the most important variables and then using this subset of variables to determine and allocate the sample.

- For highly skewed populations, include in the survey a stratum of large units that will be sampled with certainty. These large units normally account for a non-negligible part of the estimates for the population.

- Most surveys are used to produce estimates for various *domains* of interest (i.e., given subsets of the population). Take this into account in the design by stratifying appropriately (for example, by province), otherwise, it will be necessary to consider special methods at the estimation stage (see Section 2.10).

- Conduct studies to evaluate the efficiency of alternative sampling methods, stratifications and allocations. The usefulness of these studies depends on the availability and vintage of data from previous censuses, surveys and administrative data used to conduct the studies.

- During implementation of sampling, compare the size and characteristics of the actual sample to what was expected. Monitoring the sampling process can help in identifying and correct errors that can occur, such as the use of the wrong sampling fractions or the loss of questionnaires. It is also important to compare the precision of the estimates to the planned objectives.

- In determining sample allocation and size for stratified samples, account for expected rates of misclassification of units on the frame. This need arises because frames are often out of date, with the effect that classification information used in stratification is no longer entirely current. If not properly considered at the sampling stage, survey estimates will not be as precise as planned. This problem should also be addressed at the estimation stage (see Section 2.10).

- For periodic surveys using designs in which the sample size grows as the population increases, it is often appropriate to develop a method to keep the sample size stable. The *precision* of a survey is usually more influenced 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, and 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 should 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 of the reporting elements. The lower the rotation rate, the greater the precision of the estimates of change and the lower the response rate. 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.

- When it is available, use generalized sample selection software instead of tailor-made systems. One possible system to use for sampling is the Generalized Sampling System (GSAM) developed by Statistics Canada. 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 or computer-assisted modes of completion. Questionnaires play a central role in the data collection process. They have a major impact on data quality, respondent behavior, interviewer performance and respondent relations.

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 while remaining both respondent and interviewer-friendly. They 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 Development, Testing and Evaluation of Questionnaires (Statistics Canada, 1994c; see Appendix 1).

Guidelines

- Use words and concepts in questionnaires that have the same meanings for both respondents and the 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 existence. When appropriate, reuse questions from other surveys.

- Question design and wording should encourage respondents to complete the questionnaire. To this end, the questionnaire must focus on the topic of the survey, flow smoothly from one question to the next, and follow the respondents' logic in order to facilitate their recall and to 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, request the respondent's cooperation, and indicate the authority under which the survey is taken, and what confidentiality protection, record linkage plans and any data sharing arrangements are

in place (Statistics Canada, 1996a). 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 target 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 be 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 administered in person or over the telephone, 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. On the last page or at the end of the questionnaire, provide space for additional comments by respondents, and an expression of appreciation to the respondent.

- A wide range of methods can be used 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, 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, 1994c; see Appendix 1).

- 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 what the questions mean 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.

- Pretesting of the questionnaire can be conducted as an informal test that helps 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. Pretesting can also be used to suggest additional response categories that can be pre-coded on the questionnaire, and to provide a preliminary indication of the interview length and refusal problems. Debriefing sessions with interviewers can take place following a pretest in order to get their input into the (re)design process.

- Split sample testing is recommended when a need to determine the "best" of two or more alternative versions of the questionnaire exists. It 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 pretest to observe how all the survey operations, including the administration of the questionnaire, work together in practice. A pilot study is a "dress rehearsal." It duplicates the final survey design on a small scale from beginning to end, including data processing and analysis. The pilot test 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 is virtually certain to occur. To be classified as responding, the degree of *item response* or *partial response* (where a sufficiently accurate response is obtained for only some of the data items required for a respondent) must meet some threshold level below which the response would be rejected and considered *unit nonresponse* (where the sampled person, household, business, institution, farm or other unit is classified as not having responded at all).

Nonresponse has two effects on data: one contributing to an increase in the sampling variance of estimates as the effective sample size is reduced from that originally sought; the other contributing to *bias* of estimates when nonrespondents differ from respondents in the characteristics measured.

Principles

The degree to which response is pursued is based on budget and time constraints, fitness for use requirements and the risk of nonresponse bias. Adjustments are subsequently made to data to compensate for nonresponse (e.g., weighting adjustments or imputation). Decisions made about the appropriate degree of research undertaken to develop the adjustment techniques are also influenced by 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 as part of the overall considerations of data quality.

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* will be obtained in part by ensuring appropriate level of quality during all of the survey planning and implementation steps. 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);
  - target 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, periodicity of the survey);
- nature of subject matter (sensitive subjects);
- length and complexity of the questionnaire;
- follow-up methodology (if any);
- expected difficulties in tracing respondents who have moved (if applicable);
- 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;
- the 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;
- the use and effectiveness or respondent incentives.

- A pre-test can be a useful means, among others, to establish an expected response rate.

- When operational constraints permit, follow-up the nonrespondents (as a complete enumeration or on a sub-sample basis). A nonrespondent follow-up increases the response rate and can help ascertain, to some extent, whether respondents and nonrespondents are similar in the characteristics measured. A follow-up of nonrespondents is particularly important in the case of longitudinal surveys where the investment is clearly more long-term. In this case, tracing activities are of particular importance.

- 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.

- Record and monitor reasons for nonresponse (e.g., refusal, non-contact, temporarily absent, technical problem).

- Since differences between respondents and nonrespondents can cause biases in the estimates, it is important to try to determine if such differences exist. Although difficult to determine, it 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. It is however easier, in general, to compare the characteristics of the respondents and the nonrespondents to see to what extent there are differences at the level of the known characteristics. Information so gained may influence methods of compensation for nonresponse.

- There are, in general, two methods of compensating for nonresponse (Kalton and Kasprzyk, 1986): by means of sampling weight adjustment, or through the use of imputation. When appropriate, attempt to evaluate the extent to which the procedures correct for the potential bias.

- Report response and nonresponse rates. At Statistics Canada, standards and guidelines for reporting nonresponse have been established (Statistics Canada, 1992c, 1993c). Attempt to conform to standard nonresponse reporting in order to facilitate comparability between surveys. According to the guidelines, 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. Extensions of the guidelines may be needed in case of longitudinal surveys and some business surveys.

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2.7 Data Collection 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). The information is validated and then converted into an electronic format suitable for use by subsequent processes. Often this conversion involves *coding*, and sometimes it includes transmitting the data to another location. The impact of the data collection operations on data quality is both direct and critical, as the collected data are the primary inputs of a survey-taking agency. Their quality thus determines that of the final product.

Principles

Respondents, or data suppliers, especially individuals and organizations who complete questionnaires 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 the operation's high impact on the ultimate data quality, use appropriate quality and performance measurement tools to manage the process and to provide objective measures to clients (Mudryk, et al., 1996). Throughout the process, take appropriate steps to preserve the confidentiality of the information collected. (see Section 2.13).

Guidelines

- Interviewers are critical to the success of most data collection operations. Ensure that they have appropriate training and tools.

- Exploit available technology to improve the efficiency and quality of the process. Collection is often the most costly part of the survey process with significant influence on data quality. As long as there are rapid advances in communications and computing technology, it can be expected that there will be new opportunities to greatly reduce costs and risks associated with data collection or to improve response, accuracy and timeliness. Computer-assisted survey interviewing (CASI), electronic data reporting (EDR), data capture (DC2, CASES), automated data entry (ADE), and automated coding by text recognition (ACTR) are examples of new approaches that take advantage of available technologies.

- For the more complex activities performed by humans such as interviewing, manual editing, coding and data entry, statistical quality control methods are recommended to enhance the quality of collection operations. These operations should provide feedback reports for managers, participants, subject matter specialists and methodologists. These reports should contain information on frequencies of and causes of errors

- Put in place 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 steps, with a final status being recorded.

- Establish effective control systems to ensure the security of data transmission and handling. Ascertain that intruders cannot access the information. Prevent loss of information (and the resultant loss in quality) due to system failures or human errors.

- To optimize response rates and the quality of the information obtained from businesses and institutions, ensure that the appropriate person within the organization is contacted, at the appropriate time for the information to be easily available, and allowing the data to be provided using a method and format that are convenient for the respondent.

- In designing data collection processes, especially editing and coding, make procedures applied to units of study consistent across all of these units and as error-free as possible. Automation is desirable. Enabling the staff or systems to refer difficult cases to a small number of knowledgeable experts can also help. Centralization of processing is also beneficial in that it can 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 found necessary from the point of view of efficiency.

- Expenditure and other performance and quality measures gathered during the process enable the survey manager to make decisions regarding the need for redesign of the process or modification of the current one. Track actual costs of postage, telephone calls, collection vehicle production, computing, and person-day consumption. Important quality measures include response rates, follow-up rates and counts of nonresponse by reason. When these measures are available at any level 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). The frequency of editing rejects and the number and type of corrections applied to the data by stratum, collection mode, processing type, data item and language of the collection

vehicle can be compared to the expected number of rejects and corrections to monitor the quality of the data and the efficiency of the editing function. Measures of quality and productivity can be used to provide feedback at the operator or interviewer level as well as to identify error-causing elements in the design of the collection vehicle or its processing procedures.

- Subsequent survey processes may provide useful information regarding quality that can serve as signals that collection procedures or tools should be changed in future survey cycles. As examples, the editing or data analysis stages (See Section 2.8 and 2.15) may suggest that there exists a possibility of response bias or another collection-related problem. Therefore seek and obtain feedback from subsequent processes.

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2.8 Editing

Scope and Purpose

Data *editing* is the application of checks that identify missing, invalid or inconsistent entries or that 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). Data from previous collections of the same survey or from other sources may also be used.

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 a 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.

While 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, 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 likely the single most expensive activity of the sample survey or census cycle, estimated to account for as much as 40% of the total survey budget in the case of business surveys (Gagnon, Gough, and Yeo, 1994). 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.

- Editing is well suited for identifying fatal errors (Granquist and Kovar, 1997), since for this task, the 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.

- Query edits (Granquist and Kovar, 1997) are generally the ones that are responsible for the high cost of editing. This form of editing results in manual procedures, respondent follow-up, and, more often than not, little or no change to the data. Rationalize this type of editing, and find an appropriate balance between error detection and cost.

- *Hit rates* of edits, that is the proportion of warnings 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. As a result, potential efficiency gains can be had by editing in a selective manner (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.

- 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 are erroneously considered as data corrections. It can be argued that a point in time exists during the editing process when just as many errors are introduced as are corrected. A concerted effort is needed to identify and respect this logical end of the process.

- Automation allows survey managers to increase the scope and volume of checks that can be performed. Control this temptation. In other words, make it possible for some records to pass all the edits. Instead of increasing the editing effort, redirect resources into higher pay-off activities (e.g., data analysis, response error analysis, etc.)

- Attempt to limit the reliance on editing to fix problems after the fact, in particular 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, look upstream 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, etc.

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

- Do not underestimate the editing process' ability 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 non-sampling 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, in order to identify best practices.

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2.9 Imputation

Scope and Purpose

Imputation is the process used to resolve problems of missing, invalid or inconsistent responses identified during editing. This is done by changing some of the responses or missing values on the record being edited to ensure that a plausible, internally coherent record is created. Some problems are eliminated earlier through contact with the respondent or through manual study of the questionnaire. It is generally impossible to resolve all problems at these early stages due to concerns of response burden, cost and timeliness. Imputation is then used to handle remaining edit failures, since it is desirable to produce a complete and consistent file containing imputed data. Imputation can best be done by those with full access to the microdata and in possession of good auxiliary information.

Although, imputation can improve the quality of the final data by correcting for missing, invalid or inconsistent responses, take care to choose an appropriate imputation methodology. Some methods of imputation do not preserve the relationships between variables or can actually distort underlying distributions.

Principles

Imputation may be automated, manual or a combination of both. Good imputation limits the bias caused by not having observed all 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 the edits.

Imputation methods can be classified as either stochastic or deterministic, 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 (with a certain interpretation) nearest-neighbour imputation. These methods can be further divided into those methods that rely solely on deducing the imputed value from data available for the nonrespondent and other auxiliary data (logical and historical) and those methods that make use of the observed data of other responding units for the given survey. Use of current observed data can be made directly by transferring data from a chosen donor record (hot deck and nearest neighbour) or by means of models (ratio and regression). *Stochastic imputation* methods include the hot deck, regression with random residuals, and any other deterministic method with random residuals added.

Guidelines

- The imputed record should 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.

- The imputed data for a record should come from as few donors as possible. In addition, and depending on the availability of the predictor variables, the imputed record should closely resemble the donors selected. Operationally, this may be interpreted to be one donor per section of questionnaire, since it is virtually impossible to treat all variables at once for a large questionnaire.

- For large surveys, to reduce computational costs, it may be necessary to process variables in two or more passes, rather than in a single pass. This makes it difficult to follow the guidelines exactly: more than one donor may be used, and more than the minimum number of variables may be imputed. If there are extensive response errors on a record, then it may be necessary to impute more than the minimum number of variables, whether by manual or automated imputation.

- Equally good imputation actions, based on the available donors, should have an appropriate chance of being selected to avoid falsely inflating the size of important groups in the population.

- Imputed records should be internally consistent.

- 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 use of techniques to measure the variance introduced by imputation (Rancourt et al, 1993). This information is required to satisfy Statistics Canada Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 1992).

- 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 in the aggregate not very much has changed, 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 significant impact, for example with changes to large units or with large changes 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.

- During development of imputation methodology, it should be noted 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) (Kovar et al, 1988, Cotton, 1993) for quantitative economic variables and the Numerical Imputation Method (NIM) (Bankier et al, 1994) for categorical and some continuous data from the Census.

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2.10 Estimation

Scope and Purpose

Estimation is a process that consists of assigning values to unknown population parameters by using information from a data set. The parameters that are to be estimated can mostly be expressed as functions of population totals. Examples include simple descriptive statistics such as totals, means and ratios, as well as more complicated analytical statistics such as regression coefficients. Measures of *precision* are usually associated with these estimated parameters. While the quality of the computed estimates is in large part dependent on the preceding survey steps, the choice of estimation method can also play an important role, in particular when appropriate use of auxiliary data can be made.

Principles

Good estimation methods will yield *design consistent estimates* when there is no nonresponse. The basic consistent estimator is the *Horvitz-Thompson estimator*. It weights data with weights equal to the inverse of the inclusion probability generated by the sampling design. Such a weight is called a *sampling weight* and can be thought of as the number of times that each sampled unit should be duplicated to represent the full population. At times, there is need to adjust the sampling weights, for example, to adjust for nonresponse or incorporate auxiliary information to improve the precision of the estimator. The incorporation of auxiliary data in the estimation process is known as *calibration*, and the resulting factors are known as *calibration factors*. The products of the calibration factors (adjusted for nonresponse) and the sampling weights are known as *calibration weights*. These calibration weights incorporate the sampling design with the auxiliary data. Such adjustments will generally result in estimates that are approximately design consistent, and the bias is usually negligible. The proper estimated variance of the resulting estimators reflects both the sampling design and the use of the auxiliary data.

Guidelines

- Proper estimation conforms with the sampling design. To that end, sampling weights are incorporated in the estimation process. This implies that aspects of sampling design such as stratification, clustering, and multiple phase or stage information are reflected in the estimation.

- 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.

- Adjustments for nonresponse may lead to biased estimates if the nonresponding and responding units within the same nonresponse adjustment class behave differently. Even if the responding and nonresponding units behave similarly, nonresponse treatment methods themselves (reweighting, imputation) may also introduce a bias. Attempt to reduce the impact of these biases.

- When the original classification of sampling elements has changed between the time of sample selection and estimation, *domain estimation* should be considered so the new classification is reflected in the estimates. Domain estimation refers to the estimation for specified subsets of the population (or *domains* of interest). Often the elements entering into these subsets have not been, or could not be, identified before sampling. Domain estimation is usually achieved by setting to zero the characteristics of the sampled elements that are found to be outside the specified domain of interest; otherwise the characteristics take their own original measured values.

- Rely on the sampling design and sample allocation to meet the requirements of small domains of interest (Singh, Gambino and Mantel, 1992). If this is not possible at the design 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 (Ghosh and Rao, 1994).

- Provide estimated standard errors or coefficients of variation for point estimates as a measure of precision. If appropriate, confidence intervals can be provided. The measures of precision should incorporate the sampling design and any adjustment of the data such as adjustment for nonresponse (Rao, 1996; Gagnon, et al., 1996). If appropriate, consider domain estimation.

- Dead units included in the sample are assigned a value of zero in the estimation process. The resulting estimated variances will be increased since their computation will include zero values.

- 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. The use of auxiliary data can differ within the same data set, that is, different variables can enter a regression fit, leading to different estimators.

- Whenever some auxiliary data are available together with known population totals, it might be useful to use 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 spread of the weights resulting from the calibration. A large heterogeneity of weights can lead to an increase in the variance of the produced estimates, and hence a decrease in their precision. Reducing the spread of the weights can be achieved by bounding the weights as in Huang and Fuller (1978) or as in Deville and Särndal (1992). These bounding methods can also be used to avoid negative or excessively large weights.

- Outliers often lead to unreliable estimates for continuous variables. Outliers might be due either to extreme values measured for some characteristics, or to large weights attached to the outlying elements, or both. When outliers are due to extreme values for some characteristics, consider using objective procedures such as outlier-resistant (robust) estimators (Chambers, 1986). When outliers are due to large weights, reduce these weights by applying objective procedures affecting the weights (Hidiroglou and Srinath, 1981; Lee, 1995).

- 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, 1996). One of these estimation methods is referred to as *composite estimation*. These methods basically treat the data from previous occasions as auxiliary variables.

- Whenever possible, use generalized estimation software instead of tailor-made systems. Possible software packages to use are the Generalized Estimation System (GES) developed by Statistics Canada (Estevao, et al., 1995), SUDAAN (Shah, et al., 1989), PC CARP (Schnell, et al., 1988), or WesVar PC (Brick et al., 1997). 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 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.

Principles

Seasonally adjust a time series only when there is evidence that the series is influenced by seasonal forces, and when the underlying seasonality can be identified reliably, that is, when seasonality is not obscured by a high degree of irregular fluctuations present in the series (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 produced estimates need to undergo minimal revision as more data are added to the end of the series. 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. 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).

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.

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.

Guidelines

- Before seasonally adjusting a series for the first time, conduct a thorough seasonal analysis to assess if seasonality 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 recommended that the seasonally adjusted value be revised only once 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 by raking the components, without modifying the unadjusted ones. The choice between an indirect and a raked-direct approach will depend on whether residual seasonality is present and/or on the smoothness of the seasonally adjusted total (Lothian and Morry, 1977).

- Wherever seasonally adjusted figures pertaining to the same economic activity are published, coordinate the seasonal adjustment options applied by the areas involved. In particular, make consistent choice between direct and indirect adjustment of composite series, as well as between concurrent and forecast seasonal factors.

- Use the Henderson moving averages, available in the X11ARIMA/88 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 ratio, which measures the relative importance of the irregular variations in the seasonally adjusted series (Shiskin, et al., 1967).

- Do not publish the trend-cycle estimate associated with the last data point: it is subject to large revisions, and often to a reversal of movement when the next data point is added to the series (Dagum and Laniel, 1987).

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2.12 Data Quality Evaluation

Scope and Purpose

Data *quality evaluation* refers to the process of evaluating the final product in light of the original objectives of the statistical activity, in terms of the data's accuracy or reliability. Such information allows users to make more informed interpretations of the survey results, and is also used by the statistical agency to improve surveys.

Two general types of data quality evaluations can be distinguished:

Certification or *validation* is the process of reviewing the data prior to official release to ensure that grossly erroneous data are not released, or to identify data of marginal quality. It is often conducted concurrently with an interpretative analysis of the data. Because it is usually done within tight time constraints, it is limited to methods that can be implemented quickly.

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

Principles

Users need to be able to assess the degree to which errors in the data restrict their uses of these data, but few users are in a position to assess independently the accuracy of the data produced by a statistical agency. The statistical agency therefore has a responsibility to conduct the data quality evaluations required and to disseminate the results of such evaluations to its users in a timely and easy-to-use fashion.

Data quality evaluations are also of benefit to the statistical agency. To the extent to which errors can be traced to specific steps in the survey process, such evaluations can be used to improve the quality of the next occasion of the survey, and of other similar surveys.

Timeliness of the results of data quality evaluation is as important as the timeliness of the data themselves. The ideal situation occurs when the results of a data quality evaluation are of sufficient quality and timeliness to be used to improve the actual data that are released; for example the results of a coverage measurement study might be used to offset coverage differences between the frame and the target population. Where this is not feasible, then the evaluation results need to be at least timely enough to assist users in their analysis of the data and to help survey staff engaged in designing the next occasion of the survey.

Guidelines

- Managerial discretion is needed to determine the appropriate amount of data quality evaluation for a given statistical program or product. Factors to consider include the uses and users of the data, the potential for error and its significance to the use of the data, the variation in quality over time, the cost of the evaluation relative to the overall cost of the statistical program, the potential for improvement of quality, efficiency or productivity, the utility of measures to users and their ease of interpretation, and whether the survey will be repeated or not.

- 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, 1992c; see Appendix 2). For censuses and survey data, the minimum requirements include a measure or a rating of coverage error, a response rate or imputation rate, and (in the case of sample surveys) measures of sampling error for key characteristics.

- Supply a data quality rating based on expert judgement or subjective analysis when it is not possible for data quality evaluations to result in quantitative measures due to the nature of the data product, the specific user, or for reasons of timeliness, cost or technical feasibility.

- Make planning of data quality evaluations part of the overall survey design, as the information needed to conduct such evaluations often must be collected during the implementation of the survey process.

- For repeated surveys or statistical activities, it may not be necessary or feasible to undertake detailed quality evaluations on an ongoing basis. However such studies can be undertaken periodically, not simply when problems arise, to determine whether the activity is still meeting its objectives.

- Involve users of the results, whether they are external or internal to the statistical agency, in setting the objectives for the data quality evaluation program. Where circumstances permit, also involve them in the evaluation process itself.

- Consider using certification methods such as:
  - checks of consistency with external sources of data, for example from other surveys or from previous occasions of the same survey;
  - internal consistency checks, for example calculation of ratios that are known to lie within certain bounds (sex ratios, average value of commodities, etc.);
  - unit-by-unit reviews of the largest contributors to aggregate estimates, typically the case in business surveys;

- calculation of data quality indicators such as nonresponse rates, imputation rates and coefficients of variation;
- debriefings with staff involved in the collection and processing of the data;
- "reasonableness" checks by knowledgeable subject matter experts, including pre-release external review in the form of "work in progress."

- Sources of error that can be considered for evaluation include the following:
  - *Coverage errors*, which consist of omissions, erroneous inclusions, and duplications in the frame used to conduct the survey. Since they affect every estimate produced from the survey, they are one of the most important types of error. Coverage errors may cause either a positive or negative bias in the data, and the effect can vary for different sub-groups of the survey universe.
  - *Nonresponse errors*, which occur when the survey fails to get a response to one, or possibly all, of the questions. Nonresponse causes both an increase in variance, due to the decrease in the effective sample size and/or due to the use of imputation, and may cause a bias if the non-respondents and respondents differ with respect to the characteristic of interest.
  - *Measurement errors*, which occur when the response received differs from the "true" value, and can be caused by the respondent, the interviewer, the questionnaire, the mode of collection, or the respondent's record-keeping system. Such errors can be random in nature, or they can introduce a systematic bias into the results.
  - *Processing errors*, which can occur at the subsequent steps of data editing, coding, capture, imputation and tabulation. Like measurement errors, processing errors can result in either a variance or a bias.
  - *Sampling errors*, which occur when the results of the survey are based on a sample of the population rather than the entire population. In practice, these may also include *estimation errors*, which may be introduced due to the use of estimators that introduce biases, deliberately or otherwise, e.g., some small area estimators.

  A good discussion of the topic can be found in Lessler and Kalsbeek (1992) and in 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 negative 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. The indirect impact of a vigilant disclosure control / confidentiality protection program on the quality of the agency's data is the program's significant contribution to both the high response rates the agency's surveys enjoy and 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'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 income. It is important to note that there is no reference to any time limits on the protection of information from disclosure in the legislation. As well, the public perception that the agency is vigilant in protecting the

confidentiality of its data holdings is at least as important as the reality of what the agency actually does to protect respondents from disclosure of their data.

Guidelines

- Distinguish between *tabular data* and *microdata* releases. In the case of microdata, anonymized records for individuals are produced, whereas for tabular data, the data are released in the form of statistical tables, sometimes over many dimensions. Tabular data can also be classified into *frequency tables* or *tables of magnitudes*. Frequency tables give only counts (or estimated counts) corresponding to the number of individuals 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. Measures that ensure confidentiality protection for these diverse products are necessarily very different.

- In the case of magnitude data, the rows and columns are usually classification variables such as geography, industry, or, sometimes, size. These are often referred to as *key variables*, or *quasi-identifiers*, since they correspond to variables that can be used to help identify a unit.

- A table of magnitude data is deemed to be sensitive (i.e., not releasable) if any of the individual cells are sensitive. The criteria for sensitivity are usually based on simple rules that are generally believed to guard against disclosure of an individual's characteristics.

- There are usually two criteria used to establish the sensitivity of a cell. One is the number of respondents in the cell, the other is based on measures of concentration or predominance for 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 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 rules that are based on measures of concentration. The easiest ones to implement are rules that are based on linear combinations of the order statistics. One common such rule is known as the *(n,k) rule*. In this case, a cell is sensitive if the largest n respondents 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 *C-times rule* also measures concentration. An example of such a rule occurs when the ratio of the largest unit's value to the sum of the values of the third largest and all lower ranking units' values is controlled. The rationale here is to ensure that the second-ranking respondent cannot obtain a good estimate of the largest unit.

- Zero frequency cells can also reveal sensitive information in tables of magnitude data. For example, disclosure may occur if it is revealed that profits never exceed a certain value for a certain class of business.

- Sensitive cells are generally deleted 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, it is necessary to find complementary cells to suppress in order to protect the sensitive cell. Sophisticated software exists that accomplishes these tasks.

- Other methods besides cell suppression are also available. One is to change the row and column definitions, by *collapsing* categories or by regrouping or *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. Recently, methods that perturb only the largest units have been studied. Besides the addition of noise to the microdata, any other procedure to make the 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. Random rounding can also be used.

- 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. In general, controls are needed when the distribution for a given row or column is concentrated in a small number of categories.

- Other special rules may also be used for frequency tables, especially when one of the rows or columns is some grouping of a magnitude variable (e.g., income range). For example, one might control the possible range of values in a particular row or column to be sufficiently large.

- 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 safe the microdata file from which the tabulations are run.

- In the case of microdata releases, individual records rather than aggregated data are being published, and the disclosure criteria for such files are thus very different. Essentially, the legislation requires that no individual on a microdata file can be identified. For this purpose, we usually define a set of *key variables*. These variables are identifiers that an intruder may have about an individual. If a combination of these key variables leads to a unique individual (or some small number) in the population, then the risk of disclosure is high.

- 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 coarser, top and bottom coding, removing some of the variables from some respondents, or removing 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 it is often necessary to determine this 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.

- Although there are many rules for ensuring confidentiality protection, the rules cannot completely 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 in this area is needed to ensure that as much data can be released as possible, without violating the confidentiality requirements.

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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, the Statistics Canada Daily; CANSIM or some other electronic format including the Internet (e.g., Trade Data); a paper publication; microfiche; a microdata file available to authorized users or for public use; a telephone or facsimile response to a special request; or a public speech, presentation or television or radio interview.

Principles

It is important that attention be paid to the delivery of information to users to ensure that it is accurate, complete, accessible, understandable, usable, timely, meets confidentiality requirements and is appropriately priced. 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 the following two sections on data presentation and analysis and on documentation are relevant to data dissemination. Several Statistics Canada policies are concerned with dissemination (Statistics Canada, 1985a, 1985b, 1986b, 1986c, 1987a, 1988, 1992a, 1992b, 1993a, 1993b, 1994a, 1994d) but are not elaborated upon here except where they are related to quality. Thus, for example, specific policies related to licensing, copyright and announcement in the Daily, although important considerations for data dissemination in general, are excluded from these guidelines.

Guidelines

- Many steps usually take place in the preparation of released data from a statistical activity's source file. Therefore, verify the released data to ensure that they are consistent with the source data from which the released data were prepared. Note that consistency does not necessarily imply identity. For example, in the case of regrouped data or with derived variables, the data released may not actually be on the source file, but need to be consistent with data contained on the source file.

- Where data validation by an external organization is necessary and where significant benefits to data quality are anticipated or have been previously demonstrated, unreleased 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, 1992c; see Appendix 2).

- Provide documentation along with the disseminated material that contains, as appropriate, descriptions of its quality and the methodology used (Statistics Canada, 1992c). 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.

- Dissemination of a product with a look and feel common to other Statistics Canada products 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.

References

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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, often presented in the form of a published analytical article, in order to add value to the statistical output. The basic steps in the analytic process consist of examining an issue, asking meaningful questions, developing support for the answers and communicating that story to the reader. Data analysis is one of the most crucial steps of a survey in terms of its impact on data quality, as the quality of the analysis and how well it is communicated can substantially add to or detract from all the preceding steps in the survey process. A good analysis of relatively poor quality data is often worth much more than a poor analysis of good quality data.

Data analysis also helps identify data quality related problems and influences future improvements to the survey process. Analysis can justify the program's existence and underscore its usefulness or, conversely, can identify programs that cannot shed light on issues or that produce data that are not fit for use. Analysis is essential for the provision of feedback from previous surveys and pilot studies to the planning of new statistical activities, for providing essential information on data gaps, for survey design, and for the formulation of realistic objectives regarding quality.

Principles

A statistical agency's output is concerned with what the data can tell users about an issue or a decision they have to make. As such, knowing the audience and the issues of concern to them enables the analyst to identify relevant topics and techniques of analysis. Target audiences may vary widely in their knowledge of social and economic affairs, as well as in their knowledge of data analysis methods, so it is necessary that authors of analytic articles assess their audience at the outset.

Relevant data analysis produced by statistical agencies is often expected to shed light on issues of public policy. While analysts need not shy away from pointing out the policy implications of the data, it is not the job of a statistical agency to tell the government what policies or programs to adopt. The data and their analysis can be put in a "real world" context without advocating a particular policy or program.

An effective data analysis focuses on ideas, not data. It focuses on the findings, the issues and the themes. Depending on the audience, it may be worth leaving out less relevant details in order to ensure that the main message is communicated clearly.

Guidelines

- Perform issue-oriented rather than data-oriented analysis. Avoid the common trap of basing an article on the question, "What can I say about subject x using data set y?" Whenever possible, draw on more than one source of data, both from within and outside the statistical agency.

- Articles need not attempt to address an issue in all of its detail. It may not be possible to address the broad issue each time, but it is often possible to put a smaller issue in a broad context and look at the smaller issue. It is frequently the case that several issue-oriented articles can come out of one data set.

- Issue-oriented articles are generally preferable to "profile" articles, which focus solely on the data. Profile articles fail to provide a story line and are merely a "bus tour" of the survey results, passing through available variables and pointing out the highlights. While appropriate in some circumstances, such as an initial data release, such articles are not particularly interesting or illuminating and add only minimal value to the data themselves.

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

- Take the design into account in the analysis of data collected using complex survey designs. This is appropriate because the observations cannot be considered as a random sample of independently and identically distributed random variables. Incorporate the survey (calibration) weights and the variance / covariance structure of the estimates in the analysis.

- Consult the Data Analysis Resource Centre (DARC), which provides specialized services in the analysis of statistical data, including data from complex surveys, census data, and administrative data.

- Be cautious in drawing conclusions concerning causality. In the absence of certainty that a specific cause is the only one consistent with the facts, cite all possible explanations, not just one.

- 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.

- 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.

- Before beginning to write, prepare an outline of the article. An outline forces authors to answer such questions as: "What issue am I addressing? What material do I want to highlight, and how? Can I eliminate any irrelevant data? Is my message interesting?" A commonly used and often effective structure has three parts: an interesting question (the introduction), a logical organization of the evidence used to answer the question (the body), and the answer (the conclusion).

- Focus articles 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. Loss of precision may be an acceptable tradeoff for more readable text.

- Use graphs in preference to or in addition to text or 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"). Help readers understand the information in the charts by discussing it in the text.

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

- Document rounding practices or procedures. In the presentation of rounded data, use the number of significant digits that is the maximum number consistent with the utility of the data. Define the base used for rates.

- Check for errors in the article. Check the details, e.g., consistency of figures used in the text, tables and charts, verification of 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.

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2.16 Documentation

Scope and Purpose

Documentation constitutes a record of the statistical activity, including the underlying concepts, definitions and methods used in the production of the data. It also includes descriptions of influences affecting comparability of data and of data 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 that includes not only what decisions were made, but also why they were made, will provide information 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 part of the survey may be aimed at one of several different groups, such as management, technical staff, planners of other surveys, and users. Provide documentation that is 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 documentation 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 medium of dissemination, the range and impact of uses of the data, and the total budget of the statistical program. Detail provided on data quality will depend on the uses of the data, the potential for error and its significance to the use of the data, the variation in quality over time, cost of the evaluation of data quality relative to the overall cost of the statistical program, potential for subsequent improvement, and the utility of data quality measures to users (Statistics Canada, 1992c; 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 are reflected in the design of the questionnaire and the analysis of test results.

- Content: Include the questionnaire used and concepts and definitions. To facilitate integration with other sources, use standardized concepts, questions, processes and classifications. 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.
- Methodology: Set out design alternatives. Deal with issues such as target population, frame, coverage, reference period, stratification, sample design, sample size and selection, collection method and follow-up procedures for nonresponse, estimation, 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 documentation of 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 if 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 verifiers.
- Data quality: For general use, include coverage, sampling error, non-sampling error, response rates, edit and imputation effect and rate, 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 by, the project).

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

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 programs, for example, income tax collection. 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 created.

Administrative records present a number of advantages to a statistical agency or to analysts. Since they already exist, costs of direct data collection and further burden on respondents are avoided. They are usually available for the complete universe, and hence, they are most of the time not constrained by sampling error limitations. Most importantly, they can be used in numerous ways in the production of statistical outputs. Examples of their uses include: (i) the creation and maintenance of frames, (ii) the complete or partial (via record linkage) replacement of statistical collection, (iii) editing, imputation and weighting of data from statistical collection, and (iv) the evaluation of statistical outputs.

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, but administrative records start with a huge advantage in the avoidance of further data collection costs and respondent burden. 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 use of administrative data may require the statistical agency to implement a number, but most of the time 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 quality goals (e.g., to compensate for the outgoing quality from the data capture, which is often uncontrolled).

Guidelines

- Many of the guidelines from earlier sections are applicable to administrative records. Sampling and data capture guidelines will be relevant if administrative records only exist on paper and have to be coded and captured. Editing and dissemination guidelines 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. Therefore, programs should be prepared to explain and justify the public value and benignancy of this secondary use.

- Understand the limitations of the administrative records. The considerations of the administrative organization that dictate the creation of the administrative records have a profound impact on: (i) the universes covered, (ii) the concepts and definitions, (iii) frequency and timeliness, and (iv) the quality of the recorded information. The longevity of the source and its continued scope is also in the hands of the administrative organization. Consequently, the use of administrative data in statistical programs needs to be carefully studied and implemented to minimize these negative impacts on output quality.

- The administrative considerations that dictate the concepts, definitions, coverage, frequency, timeliness and other attributes of the administrative program may, over time, undergo changes that will distort time series derived from the administrative source. Be aware of such changes, and deal with their impact on the statistical program.

- Whenever individuals or businesses benefit or lose, based on the information they provide to the administrative source, there may be biases in the information supplied. Special studies may be needed in order to better understand and assess these sources of error.

- 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 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.

- Collaboration with the designers of new or redesigned administrative systems can help to build statistical requirements into administrative systems from the start**.** Such opportunities do not happen very often, but when they do, the eventual statistical value of the statistical agency's participation can far exceed the time expended.

- Understand and document concepts, definitions and procedures underlying the collection of the administrative data. This information, especially the definition of the universe covered, is needed for assessing the fitness for use of data derived from administrative records. This will facilitate any editing or adjustment procedures needed to integrate administrative data within statistical frameworks, and for informing users. Pay special attention to definitions and procedures used for geographic coding of records if they are to be used for small area data.

- 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 how these data are put together. This 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 first using an administrative source for statistical purposes, investigate the quality of each data item on the record layout. 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 or industrial activity) might not be sufficient for statistical use. In that instance, the statistical agency may choose to improve the classification codes or to use those available, but in a more limited way (e.g., use only a high level of the classification).

- Just like data collected by means of a survey, administrative data are also subject to partial and total nonresponse. Therefore it is important to set up an edit and imputation or a weight adjustment procedure to deal with this nonresponse. In some instances, the lack of timeliness introduces further gaps that may be addressed by imputation or weight adjustment. When implementing an edit or an imputation procedure, guidelines listed in sections 2.8 and 2.9 should be followed. In addition, as part of the edit and imputation process, give special attention to the identification of active and/or inactive units. Do not impute the latter units. Some imputation may also be required in the case where some of the units report the data at a different frequency (e.g., weekly, quarterly) than the frequency (e.g., monthly) of most of the units.

- Some administrative data are longitudinal in nature (e.g., income tax, goods and services tax) and units are assigned an identifier that allows for linkage of data from different reference periods. The identifier should be used with care, as a unit may change identifier over time. Track down such changes to ensure proper temporal data analysis. In some instances the same unit may have two identifiers for the same reference period, thus introducing duplication on the administrative file. If this occurs, an unduplication mechanism should be developed. Some administrations provide common identifiers between different administrative files. Again, the quality of these linkages should be assessed.

- 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, statistical matching (i.e., matching of records with similar statistical properties) may be a reasonable choice (see Cox and Boruch, 1988 and Scheuren and Winkler, 1993).

- When record linkage of administrative records is necessary (e.g., for tracing respondents, for supplementing survey data, or for data analysis), it must conform to the agency's policy on record linkage (Statistics Canada, 1986). Privacy concerns that may arise when a single administrative record source is used are multiplied when linkage occurs with other sources. In such cases, the subjects may not be aware that information supplied on two separate occasions is coming together. 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.

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

- 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 and the Policy on Informing Survey Respondents (Statistics Canada, 1996) has to be followed in this regard. When consent is not obtained, put collection procedures in place for the equivalent survey questions to be asked from the respondents.

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3. THE MANAGEMENT CONTEXT

This section outlines the management context within which these Quality Guidelines are applied. It draws together the various policies, managerial processes, consultative mechanisms, and technical procedures that have a bearing on the management of quality at Statistics Canada. While Section 2 focused mainly on the design of individual statistical activities, Section 3 provides a broader managerial and corporate perspective on quality assurance, while also referring to many of the same policies and procedures as Section 2. It provides a context for the quality guidelines contained in Section 2 and is based on Statistics Canada's Quality Assurance Framework (1997a).

3.1 Quality at Statistics Canada

Our product is information. The effectiveness of the organization depends on the relevance and credibility of that information. Relevance is maintained and enhanced in an environment of changing and expanding user requirements and expectations. The credibility of our information is based on the organization's reputation for reliable data and supported by all our products. Since few users can assess independently the reliability of the information we produce, our "name" is their continuing source of confidence. Therefore, a concern for quality must permeate all that the agency does.

The quality of statistical information is multidimensional. Quality embraces not only the attribute of relevance, but also the characteristics of accuracy, timeliness, accessibility, interpretability and coherence. Within and across statistical programs and products, quality also incorporates characteristics of consistency, compatibility and completeness. Each statistical product is itself multidimensional, containing a range of information that may vary in quality and serve many data uses. Across statistical programs there are differing objectives, priorities, constraints and opportunities, and thus differing quality characteristics.

Quality is not something that should or can be maximized at all costs. The challenge of defining the agency's overall statistical program is to establish and maintain over time an appropriate balance between the quantity and the quality of the information yielded by that program with the resources available. The challenge of the design of individual statistical programs is to make the appropriate trade-offs among the evolving needs of clients, costs and respondent burden, and the various dimensions of quality.

Given the central importance of quality to the agency, the management of quality needs to be built into the management and technical practices of the Agency. It needs to be built into the design of individual programs and managed by these programs.

Statistics Canada strives to build quality 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 budgetary circumstances, and to the changing reality that is the

object of measurement. A concern for, and pride in, quality must be shared by employees and managers at all levels in Statistics Canada. Acceptable quality is not achieved by managerial actions, edicts and checks. It is achieved through understanding client needs and the sound application of knowledge and expertise at many levels. It requires motivated and competent human resources, and the effective development and management of these resources and their activities. To this end, Statistics Canada has in place a series of human resource programs, together with the policies, procedures, and guidelines needed to promote, facilitate, and fortify activities and behavior consistent with the agency's central concern for quality.

3.2 Organization and Infrastructure for Management of Quality

Statistics Canada is organized into three statistical program fields each encompassing specific subject matter groupings: a management services field, a statistical operations field, and a technical infrastructure (geography, technical classifications, informatics and statistical methods) field. Supporting these "functional" fields are internal management and subject matter committees, and consultative and professional advisory committees that have mainly external membership.

Each of the *management committees* is responsible for providing guidance, policies or management for a major function or responsibility across the agency. These include, for example, the Corporate Planning Committee, the Methods and Standards Committee, the Training and Development Committee, the Recruitment and Development Committee, and the Dissemination Committee. The primary management committee overseeing the activities of the agency is the Policy Committee.

The *subject matter committees* fulfill coordination functions across statistical programs to promote various aspects of quality within particular areas of subject matter, e.g., demography, labour statistics, aboriginal data, environmental statistics, and income and wealth. They focus on ensuring relevance and coherence, in part through promoting the use of common definitions and classification systems, and consistent and effective meta-data.

The *consultative committees* - the National Statistical Council, the Federal-Provincial Consultative Council on Statistical Policy and its subsidiary committees - provide advice on broad policy issues, priorities, data and user requirements, and output.

Thirteen *professional advisory committees* covering major subject areas provide an ongoing review of the agency's statistical output and methods and help set priorities within these areas.

The program fields are responsible for the implementation, management and review of mandated statistical programs. For development and redevelopment they implement and manage programs through a matrix management process, using project teams. The program areas provide the professional subject matter (and some types of technical) expertise, and the infrastructure fields provide technical and operational expertise and services. Various

components of the management services infrastructure provide direct or indirect support to these undertakings (e.g., human resources, financial, training, audit and program evaluation services).

The program manager, within the scope of the approved mandate of the statistical program, is responsible and accountable for the quality of the data and of the information produced through the statistical program. The technical infrastructure and the statistical operations fields are responsible and accountable for providing scientifically sound and efficient technical and operational methodologies, systems and operations.

These arrangements provide a number of checks and balances that serve to maintain sound and consistent statistical practices.

3.3 The Quality Assurance Framework

Unlike the users of most manufactured products, the users of statistical data are generally not in a position to assure for themselves the quality of the products they receive simply by examining, testing and using them. While the relevance and timeliness of statistical data may be immediately apparent to a user, other dimensions of quality, especially accuracy, cannot be deduced from inspection of the product alone. The producer of statistical data therefore needs to have in place quality management and measurement processes that can determine the major quality requirements, build these into the data, and then provide the user with sufficient information to assess the fitness of the data for its intended uses.

Quality management requires an understanding of the potential risks and opportunities that can affect quality, and the application of appropriate managerial and scientific methods to reduce these risks and take advantage of the opportunities. Among the potential risks are, for example, losing touch with client needs, declining respondent cooperation, budgetary constraint, and skill shortages. Potential opportunities include, for example, rapid advances in technology, advances in statistical methodology, and growing needs for informed policy analysis. Careful management can turn risks into opportunities - but vice versa too.

The Quality Assurance Framework (Statistics Canada, 1997a) documents the processes in place in the agency to manage quality, within the organizational structure, and in face of risks and opportunities recognized by the agency. These processes are in essence designed (a) to support sound and informed managerial judgements about the allocation of resources, and sound and informed technical judgements based on knowledge and expertise, and (b) to ensure that the operations that flow from these decisions are carried out with due regard for quality. The elements of the Quality Assurance Framework are described under three broad headings: *Ongoing Assurance of Relevance*, *Design and Execution*, and *Environment*.

3.3.1 Ongoing Assurance of Relevance

The "*Relevance*" component 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. As the term used for this component suggests, the outcomes of these processes are the most significant determining factors in assuring the relevance dimension of quality for an individual statistical program, as well as across all programs. The processes that are used to assure relevance also permit basic monitoring of other elements of quality and correspondingly assessment of user requirements for these.

While taking into account that about 95% of the agency's budgetary resources are devoted to ongoing programs that are non-discretionary, as well as the interdependency among the different programs, the agency has put in place processes that monitor the relevance of its existing programs, that identify new or emerging information gaps that the current program is not filling, and that lead to decisions on program change or new funding initiatives aimed at strengthening the relevance of the agency's overall program. These processes can be described under four broad headings: client and stakeholder feedback mechanisms, program review, data analysis, and the planning process. The first three of these headings cover activities designed to obtain information and intelligence about client information needs, about the success of current programs in satisfying these needs, and about gaps and weaknesses in current programs. The fourth heading covers the process for deciding the changes to be made based on this information.

Client needs, however, are not only a matter of overall and individual program relevance. The other elements of quality also need to be satisfied. As part of the process of ensuring relevance and for making decisions through the planning process, it is important to assess and consider all elements of quality to be delivered. Part of this assessment is made by analyzing data outputs and reviewing processes with a view to recognizing and addressing deficiencies or inconsistencies, as well as by assessing achievements against costs.

3.3.2 Design and Execution

The "*Design and Execution*" component covers the design, conduct and evaluation of information production processes within the approved programs and subject to their budgetary constraints. Beyond establishing relevance and setting of priorities, the accuracy, timeliness, accessibility, and interpretability dimensions of data quality stem primarily from the design and execution of these processes.

In general, a project management and steering committee regime is used to ensure that statistical programs are carried out according to their mandate. A mixture of functional and matrix management approaches ensures that the appropriate mix and quantity of resources and expertise are planned for and available to the project. Furthermore, it provides a

mechanism to review, monitor and report on progress, problems and issues; and to ensure the proper interpretation of the mandate and objective, and that appropriate judgements are being made and implemented. The exact nature of practices will be a reflection of the size, relevance, complexity and nature of the program, as will the resources applied to it.

The use of an interdisciplinary project team/project management approach for design and implementation, supported by the functional organization, is important in ensuring that quality considerations receive appropriate attention. In particular, methodologists on project teams have an explicit responsibility to bring their expertise on data quality trade-offs to bear on the project. The fact that they are part of a specialized functional organization facilitates the full development of their expertise. It also permits calling on a variety of specialized resources and, when warranted, calling on the higher management of this organization to help resolve conflicts that could not be resolved within the project team.

The collection or acquisition, processing and compilation of data requires the use of sound statistical and analytical methods and models, effective designs, instruments, operational methods and procedures, and efficient systems and algorithms. The quality achieved - accuracy, 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 the implemented program. The individual program managers have considerable flexibility in implementing specific practices and methods. The definition and criteria for acceptable quality are left to the individual program to determine and justify within its circumstances, constraints, opportunities and objectives, and within the mandate approved by the Policy Committee.

Whatever specific methods are applied, they need to be within the realm of commonly accepted and defensable statistical practices under the given circumstances. The use of new technologies and innovations to improve quality and efficiency is typically encouraged, but should be well tested to minimize risk. Questionnaires, in particular, must be tested to ensure that respondents can and will be willing to provide input data of acceptable quality. It is important to be able to monitor quality, react effectively to unanticipated problems and verify or support the credibility of the results, as well as understand their limitations. The specific practices and methods applied may change over time as a result of policy decisions or as a result of ongoing assessment by the individual programs.

At the design or redesign phase and as part of ongoing reviews, there are technical assessments of methods proposed or in place, as well as evaluations of operational effectiveness and cost performance. These serve as a test of the suitability of the technical proposals or practices. They also serve to improve and guide implementation of specific components of methodology and operations, within and across programs.

Besides being used to inform and to describe statistical phenomena and to recognize data gaps, data analysis is also a means to assess or to measure the accuracy and coherence of

data. In this context, the results of analysis may lead to, for example, additional or modified data editing procedures, questionnaire design changes, supplementary data collection procedures, additional staff training, the adoption of new methods, procedures or systems, or to redesign.

The delivery of information and statistical products is the culmination of efforts to assure quality, as the products are finally conveyed to users. While all elements of quality are important to this stage, interpretability, coherence and accessibility play a critical role in the final quality of the information delivered.

3.3.3 Environment

The "*Environment*" component includes the corporate initiatives and processes designed to maintain within Statistics Canada an environment that encourages a concern for quality and the production of the best quality possible within operational and budgetary constraints. These measures include the recruitment of talented staff and their development to appreciate quality issues, an open and effective network of internal communications, explicit measures to develop partnerships and understanding with the agency's suppliers (especially respondents), programs of data analysis and methodological research that encourage a search for improvement, and the development and maintenance of standard definitions, classifications, frameworks and methodological tools to support interpretability and coherence.

The three components of relevance, design and execution, and environment, although described separately, interrelate closely. For example, there is an important feedback loop between the evaluation activities under Design and Execution and decisions about investment in programs under Ongoing Assurance of Relevance.

While the framework serves the management and assurance of quality in a coherent manner, its elements were not introduced at a single point in time in an attempt to "manage quality." It has evolved over time as part of the agency's managerial and technical evolution and reflects the central role that quality concerns play in the management of a statistical agency. The specific elements in place are the result of a wide range of ongoing activities involving every level of the agency, as well as clients and stakeholders, "suppliers" and advisory groups. It is one of the functions of project, advisory and management committees, as well as of the corporate and project planning processes to identify quality management issues, to identify and communicate "good practices" and to propose worthwhile initiatives that will promote quality.

3.4 Conclusion

Statistics Canada's quality assurance regime 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 regime depends not on any one process but on the

collective effect of many interdependent measures that build on the professional interest and motivation of the staff, and that reinforce each other with their attention to client needs, their emphasis on objective professionalism, and their concern for data quality. While any description of the overall regime inevitably appears to separate components, the important feature of the regime is the synergism resulting from the many players in the agency's programs operating within a framework of coherent processes and consistent messages.

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5. APPENDICES

5.1 Appendix 1: Policy on the Development, Testing and Evaluation of Questionnaires

Approved January 5, 1994

Background

Questionnaires play a central role in the data collection process. They have a major impact on data quality and on the image that Statistics Canada projects to the public.

A well-designed questionnaire should collect data efficiently with a minimum number of 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 are adequately tested, easy to administer, easy to process, respondent-friendly, and interviewer-friendly. This policy, therefore, establishes the requirement for the testing of new and revised questionnaires. It also establishes the requirement for the periodic evaluation of questionnaires used in on-going surveys. The policy concerns all aspects of questionnaire design that may influence data quality, respondent behaviour, and interviewer performance.

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. 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).

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 developing and 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 and again after revisions have been made as a result of testing.

4. All Statistics Canada questionnaires shall be evaluated periodically.

Responsibilities

1. Program Areas

- Ensure that all requirements for implementing this policy are in place. This includes making adequate budget provisions for developing and testing new or redesigned questionnaires.

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

- At the appropriate stage in the questionnaire design process, consult as appropriate with the Communications Division (Public Relations Section), the Dissemination Division (Forms Design and Production) and the Standards Division.

- 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, cognitive techniques, and pretesting and (b) coordinating development and testing activities that are contracted out.

- Reviews questionnaires with regards to the wording and sequencing of questions, length, format, respondent-friendliness, and interviewer-friendliness.

- Provides documentation, guidelines, and training to improve questionnaire design.

4. Forms Design and Production (Dissemination Division)

- Provides assistance in the design, layout, 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.

5.2 Appendix 2: Policy on Informing Users of Data Quality and Methodology

Approved April 7, 1992

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 and processing its data, the quality of the data it produces, and other features of the data that may affect their use or interpretation.

Data users first must be able to verify that the conceptual framework and definitions that would satisfy their particular data needs and uses 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 error in the data restricts, or further restricts, the use of these data.

The measurement and assessment of data quality, however, is a complex undertaking. There are several dimensions to the concept of quality, many potential sources of error and often no comprehensive measure(s) of data quality. A rigid requirement for comprehensive data quality measurement for all Bureau products would not be achievable given the present state of knowledge. Emphasis must, therefore, be placed on describing and quantifying the major elements of quality.

Policy

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

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 data disseminated by Statistics Canada however collected, derived or assembled, and irrespective of the medium of dissemination or the source of funding.

Responsibilities

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(s) of the Methods and Standards Committee.

6. INDEX OF IMPORTANT TERMS