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(continued on reverse)

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Guest Editorial: Health Surveillance in Canada

David Mowat

Interest in the surveillance of health-related events is growing rapidly. Surveillance systems in several provinces are undergoing further development, and there are collaborative efforts to enhance surveillance for specific disease groups (such as cancer, cardiovascular disease, diabetes and HIV/AIDS) at the national level. The National Health Surveillance Infostructure (NHSI) is a suite of seven pilot surveillance projects funded by Health Canada and conducted in partnership with stakeholders across Canada.

Developments in surveillance are taking place against a background of greatly increased activity in all aspects of health information, involving all provinces and, at the national level, the Canadian Centre for Health Information (CIHI), Statistics Canada and Health Canada. Interest on the part of the Conference of Deputy Ministers of Health in exploring a more co-ordinated approach to surveillance has led to "A Discussion Paper on an Integrated National Health Surveillance Network for Canada," written by the Federal/Provincial/Territorial Surveillance Integration Design Team. This was released in September 1998 and has been the subject of consultations across Canada.[a]

The features that distinguish surveillance from other forms of health investigation are that data are collected routinely, frequently or continuously, and they are generated from the entire population or, less frequently, from a representative sample. The process of surveillance includes not only data collection, but also integration, analysis and interpretation to produce a "surveillance product" for a specific public health purpose or policy objective, as well as the dissemination of that product to those who need to know. Surveillance does not itself constitute investigation, research, risk management or evaluation, although it makes a significant contribution of information that is essential to all of these. Surveillance may, for example, generate hypotheses, which may later be tested by other methods.

The most familiar purpose for surveillance is the identification, as rapidly as possible, of unusual events, outbreaks of disease and emerging health issues. It is worth noting that, although high quality surveillance data are always desirable, for these "early warning" purposes, a balance must be struck between timeliness and high levels of validity.

Another significant role for surveillance is to inform decisions governing the management of risks to health. This may involve public health programs, regulatory action or public policy responses, all of which are exercises in evidence-based decision making, with surveillance being one important source of evidence.

The Discussion Paper recommends several approaches.

- Improved electronic means of accessing currently collected data, together with inventories of existing databases and information on format, quality, security and contact persons
- Integration of information, whether this means taking data from different geographic areas, assembling multiple databases relevant to a health issue or integrating databases at the individual file level
- Using new technology to reduce response times and to facilitate real-time access to data
- Developing and adopting standards—for the classification of diseases, exposures and other health events, database elements, and for informatics

[a] For further information, please see the Web site <http://www.hc-sc.gc.ca/hpb/transitn/surveile.html>.

Author References

David Mowat, Director, Surveillance Transition, Health Protection Branch Transition, Health Canada, Tunney's Pasture, AL: 0701B, Ottawa, Ontario K1A 0L2

- Developing and sharing innovative electronic means of accessing, integrating, analyzing, presenting and disseminating information
- Developing policies to balance collective interests and the protection of personal privacy
- Strengthening the human resources and skills available across Canada

Partners in the proposed network will include federal and provincial governments, regional and local health authorities, academics, non-governmental organizations (NGOs) and others.

Achieving this vision will require the development of an infostructure, including a means of joint decision making in those areas where the partners have agreed to collaborate; agreements on the ownership, transmission, privacy, security, accessibility and release of data; and funding.

The paper by Choi published in this issue of *Chronic Diseases in Canada* is intended to stimulate debate on the future of health surveillance. It is instructive to consider the similarities and differences between Choi's vision of surveillance in the 21st century and that of the Design Team. There is agreement on the range of uses for surveillance data, the importance of data quality and the emphasis on making better use of existing data sources. Rather than developing a system from the ground up to provide comprehensive surveillance at the national level, the Design Team proposes to strengthen existing surveillance functions and to build on the current federal, provincial, regional/local and NGO activities. An incremental approach, which facilitates accessibility, sharing and integration of data through a distributed network, standards and metadata, is a practical and realistic means of strengthening surveillance in Canada and moving the surveillance agenda forward.

In an era of increasing interest in evidence-based decision making, the quality and completeness of the information available to decision makers must be improved. As Choi points out, surveillance has a place alongside analytical epidemiology in informing decisions about health. Surveillance contributes speed, frequent or continuous data collection and the ability to ascertain incidence and prevalence in entire populations; analytic studies can provide more information about causation. Both have an important role to play in shaping the decisions that will be taken in future to protect the health of Canadians. ■

Perspectives on Epidemiologic Surveillance in the 21st Century

Bernard CK Choi

Abstract

This paper describes the importance of epidemiologic surveillance as a systematic, ongoing and population-based system for early warning and program development in the 21st century. Such a system routinely collects data on three classes of indicators (health outcomes, risk factors and intervention strategies) to set up both an early warning system (to identify associations and make predictions on health outcomes) and a program development system (to assess the need for intervention strategies, to plan and implement such strategies and to assess their effectiveness). A comprehensive surveillance system must be systematic (evidence-based selection of indicators, not hypothesis-driven), ongoing (continuous data collection, including repeated surveys) and population-based (whole population, or representative samples of the population). Such a system need not be developed from scratch, but can be based on linkage of existing databases and collection of additional information for identified data gaps. The initial steps for selecting indicators and creating a prototype framework for a comprehensive surveillance system are proposed to stimulate further discussion. It is suggested that surveillance systems should be used more widely in public health.

Key words: *control; epidemiology; health surveillance; prevention; program evaluation; risk factors*

Introduction

Epidemiologic surveillance dates back to the time of John Graunt, who published the *Natural and Political Observations Made Upon the Bills of Mortality* in 1662.[1] Graunt's approach for the analysis of death certificates (Bills of Mortality), that volumes of data should be reduced to a few tables and that profit may be gained by analyzing these tables, is consistent with the modern technique of population-based epidemiologic surveillance.[2] In the subsequent 300 years, however, the focus of health research shifted to sample-based studies: cross-sectional, cohort and case-control studies, and clinical trials.[3–6]

In recent decades, awareness of the limitations of sample-based epidemiologic studies has grown,[7] along with recognition of the importance of population-based surveillance systems for measuring the health status of a population,[8] for early warning of emerging health risks and for program development.[9] Systematic and timely analysis of health trends has been identified as increasingly important for evidence-based policy and program development.[10,11] At the same time, biophysical and socio-economic data have become invaluable in the understanding of relationships among human health, risk factors and interventions.[12]

It appears that epidemiologic surveillance may come back full circle in the 21st century and become once again the focus of health research. (It has been suggested that epidemiologic surveillance is not research per se, and can therefore only be called public health surveillance.[13] But it is my opinion that health research can be conducted in the next century using well-maintained and well-validated surveillance databases.)

This paper offers a point of view for debate on the blueprints for a systematic, ongoing and population-based surveillance system for the 21st century, with the

Author References

Bernard CK Choi, Chief Epidemiologist, Bureau of Cardio-Respiratory Diseases and Diabetes, Laboratory Centre for Disease Control, Health Canada, Tunney's Pasture, AL: 1918C3, Ottawa, Ontario K1A 0K9; Fax: (613) 954-8286; Email: Bernard_Choi@hc-sc.gc.ca; *and* Associate Professor, University of Toronto; *and* Adjunct Professor, University of Ottawa

hope of stimulating further discussion on this very important topic.

Problems of Sample-based Studies

In a sample-based approach, investigators conduct custom-designed and mostly localized studies to investigate associations. However, these studies are prone to biases, including those that Sackett[14] called "positive results bias," "hot topic bias," "wrong sample size bias," "expectation bias" and "data dredging bias," and a number of biases reviewed elsewhere by this author.[15,16] (Population-based studies are also susceptible to these biases, but to a lesser extent than sample-based studies.)

Consider a situation where an exposure and a disease are not associated. Due to problems in study design, data collection or analysis, or by chance, a sample-based study may incorrectly determine that there is an association. When published, this false positive study can create a *hot topic bias*, that is, more investigators will become interested in the topic.

In this case, let's say 100 studies may be designed. If the type I error rate (significance level) of these studies is chosen at the conventional 0.05, then on average, 5 of the 100 studies will show false positive results. Since positive results are more likely to be submitted by investigators to scientific journals *(positive results bias)* and accepted by editors *(editor's bias)*, this will lead to an even bigger hot topic bias, and another false positive research cycle will begin. (In the case of a hot topic, it is unlikely that all of the 95 correctly negative studies will go unpublished, and letters to the editor will almost certainly follow. Although the hot topic bias could thus be somewhat self-corrected, the overall tendency for the bias remains.)

Through this biased process, an investigator can almost always "prove" something out of nothing. Results of such an unsystematic, non-population-based approach would likely focus efforts in certain narrow areas, ignoring some other major and real issues. While sample-based studies have provided a tremendous amount of knowledge, their limitations due to false positive research cycles must be recognized.

Population-based Surveillance

Early work on population-based health surveillance included cluster studies and ecologic correlation studies. In the former type of study, observation of unusual clusters of cases of a rare disease in population subgroups exposed to a common risk factor may lead to hazard identification. Ecologic correlation studies, on the other hand, seek to establish an association between exposure and disease occurrence by comparing disease rates among populations in different geographic areas subject to varying levels of exposure.[17]

An example of an ecologic correlation study that is very close to a surveillance system is the correlation study by Murata et al.[18] These researchers looked at how mortality and incidence rates of cancers of the lung, colon and rectum correlated with 63 environmental variables (including population density, number of households living on welfare aid, number of hospitals, tobacco tax revenue, sulphur dioxide level, rainfall, traffic density and meat consumption) in 583 geographic districts of Japan from 1975 to 1979. However, like other similar studies, this study failed as a surveillance system because it was not performed on a long-term basis, results were not used in the systematic development of intervention strategies and there was no systematic information dissemination. Furthermore, cluster studies and ecologic correlation studies to date are susceptible to ecologic fallacies and other potential problems.[16]

The US Centers for Disease Control and Prevention (CDC) defined epidemiologic surveillance as the "ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know."[19] More recently, Monson pointed out that, as scientists of the 21st century, "rather than conducting short-term studies that will test a hypothesis, we must be developing systems to collect data on exposure and disease that will become part of the fabric of the community, the workplace, and the health care organization."[20] The importance of a comprehensive, systematic, long-term and population-based surveillance system has been stressed.

Recent textbooks by Halperin and Baker[2] and Teutsch and Churchill[13] have summarized the basic principles of public health surveillance. However, the form, content and operating principles of a comprehensive epidemiologic surveillance system for the 21st century have not yet been described in the literature.

A Vision for Comprehensive Epidemiologic Surveillance for the 21st Century

In a comprehensive and systematic approach to surveillance, all associations with the same strength will have an equal chance of being detected. In the 21st century, scientists and public health officials should therefore concentrate more on systematic, ongoing and population-based data collection systems than on hypothesis-driven, short-term sample-based data collection. Important and useful data on health indicators, risk indicators and intervention indicators should be collected routinely, systematically and accurately for the community. (Many of the current databases may be routine and population-based, but neither systematic nor accurate.) These databases can then be analyzed systematically to monitor trends of health, risk and intervention in the community, to identify emerging health risks (early warning system)

and to develop and evaluate evidence-based disease control and prevention programs (program development system).

To develop a comprehensive early warning and program development system based on surveillance, the following three questions need to be answered.

1. What indicator variables should be included in the surveillance system?

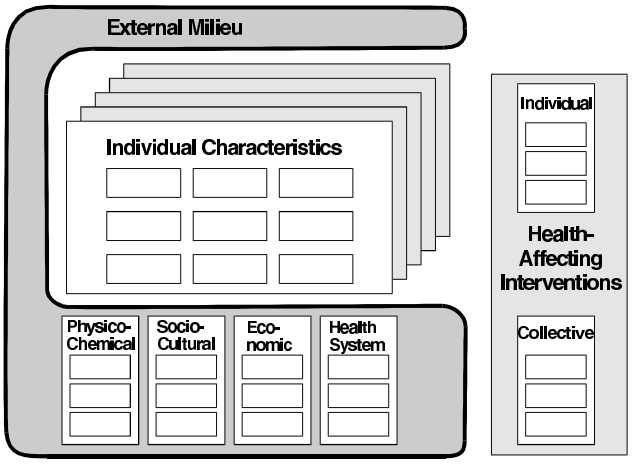
A conceptual framework for health information, the Health Template, was put forward in 1991 by the National Task Force on Health Information[21] (Figure 1). The Health Template classifies health information into three major areas—individual characteristics, external milieu and "health-affecting" interventions—with further subdivision into several levels of categories. The Health Template attempts to provide a framework for the subsets of quantitative information and a basis for possible development of forecasting and policy modelling. Therefore, it can be used potentially as a model for the selection of indicators for a comprehensive surveillance system.

The problem with the Health Template, however, is that it is too ambitious. In the current version there are 44 categories for individual characteristics, 93 for external milieu and 59 for health-affecting interventions, a total of 196. Most of these categories are described in general terms, such as "air" or "social support," without working definitions. When fully developed, the whole classification scheme of the Health Template may have too many variables for a practical surveillance system.

The list of indicator variables must be narrowed down to a manageable size for use in a comprehensive surveillance system. Several techniques may be used to select indicator variables, including literature research, Delphi surveys among experts[22–24] and experts' consensus workshops.[22] These techniques will involve development of a priori selection criteria.

FIGURE 1

A Template for Health Information: Main



Source: Adapted from Reference 21

2. Where can these data be found?

There are already many existing data sources in Canada. For example, there are national population-based databases, such as those on cancer incidence and mortality, congenital anomalities, hospital statistics and the National Population Health Surveys. Provincial population-based databases include British Columbia Health Surveillance, Manitoba Infant Deafness Surveillance, Newfoundland Disability Surveillance and Prince Edward Island Diabetes Surveillance. There are also national voluntary databases, such as those on cystic fibrosis, hemophilia, multiple sclerosis and muscular dystrophy.

In the US also, there are numerous existing databases. In addition to the CDC-funded Emerging Infections Program operating in seven states, most of the other states already have population-based surveillance systems. For example, the Behavioral Risk Factor Surveillance System, which started in 1984, now covers all 54 American states and territories. Twelve years of data (1984–1995) are now available on CD-ROM.

Record linkage of existing databases can be used to create new and more useful databases. In addition, new data collection systems will be needed for data not yet captured routinely. Currently, there are numerous potential surveillance systems that are not being used for surveillance in Canada and the US. Two of the oldest, birth certification and death certification, are not used optimally for surveillance, partly because of the poor data quality and partly because of the lack of linkage to other useful data. If, say, death records and hospital statistics (health outcomes) were linked with both behavioural risk factor surveillance data (risk factors) and programs/services data (intervention strategies), the result would be a comprehensive surveillance system that could put current public health resources to better use.

It is important to know that many of the existing databases have been created for administrative purposes (i.e. not for use by epidemiologists), have not been validated and may contain a lot of surplus information of no use to epidemiologic surveillance. Therefore, these data sources should be evaluated, validated and used for providing data only for the selected indicator variables. Data pertaining to the same indicator variables may be cross-validated from multiple data sources. The useful portions of the separate databases may be physically combined to become a central, large database for the comprehensive surveillance system. Alternatively, the various databases may remain separate, with easy access for use through telecommunications.

TABLE 1

Proposed variables for a comprehensive epidemiologic surveillance system

Health indicators	Risk indicators	Intervention indicators
Incidence of diseases	Tobacco use (e.g. prevalence and amount of smoking)	Health promotion programs
Prevalence of diseases	Demographic traits (e.g. population density)	Disease prevention and control programs
Life expectancy	Medical services (e.g. hospital beds per unit population)	Program planning deficiencies
Mortality	Socio-economic factors (e.g. unemployment rate)	
Person-years of life lost	Air pollution (e.g. sulphur dioxide)	
Quality of life	Climatologic factors (e.g. temperature, rainfall)	
Behavioural changes	Food consumption (e.g. expenditure on food per household)	
Biochemical changes	Drug use (e.g. alcohol, medication)	
	Occupational factors	
	Physical exercise	

3. What will long-term epidemiologic surveillance for the 21st century look like?

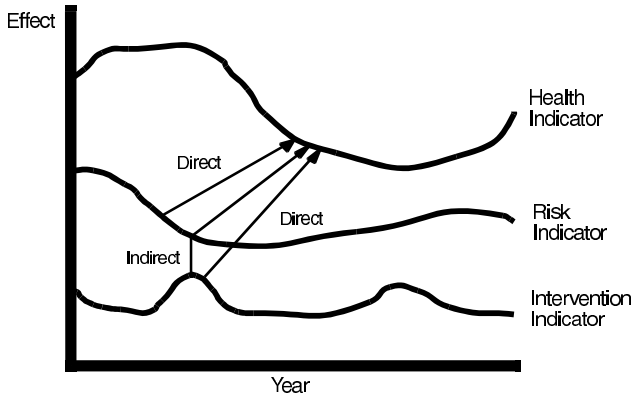
The exact form and content of a long-term, comprehensive epidemiologic surveillance system for the 21st century is not known at this time. However, it is anticipated that the system will collect data on three classes of indicators: health, risk and intervention. Potential variables for each class are proposed in Table 1.

The lists of indicators are proposed here for the purpose of inviting further discussion. For example, behavioural changes appear in one list but tobacco use and physical exercise are in another. Healthy eating is not included in any list. The actual selection of variables should be systematic and evidence-based as described in the next section, "Initial Steps."

Risk factors can directly result in changes in health trends, and interventions can directly or indirectly (through their effects on risk exposure) result in health changes. Therefore, monitoring changes in risk indicators and intervention indicators can predict health changes and identify emerging health problems (early warning). If intervention programs are effective, they are expected to cause changes in both risk exposures and health outcomes (program development and evaluation) [Figure 2].

FIGURE 2

Direct and indirect effects of risk and intervention indicators on health indicators for monitoring in a comprehensive surveillance system



Initial Steps

Initial steps for setting up a comprehensive, long-term surveillance system may include the following activities.

1. Conducting a series of round table discussion sessions to identify the stakeholders, purposes and priorities for the comprehensive surveillance system
2. Conducting an extensive literature review and literature survey to identify valid, reliable indicators of the biophysical and socio-economic environments and health outcomes; using meta-analysis[25,26] to prioritize risk variables based on relative risks and attributable risks
3. Conducting a series of Delphi surveys[22] (an initial survey to acquire indicators and subsequent surveys to rank indicators) among cross-disciplinary teams of experts to identify the set of indicator measures favoured by the experts for each of the health, risk and intervention areas
4. Conducting a series of experts' consensus workshops[22] to refine the set of indicators and to develop ground rules and working definitions for the early warning and program development system for the chosen health outcomes
5. Determining the availability of existing databases for these indicators, how to access such databases and how multiple databases can become part of a comprehensive surveillance system

6. Evaluating the quality and developing methods for improving the quality of such existing databases
7. Identifying gaps in data availability and developing methods for collecting additional information for the surveillance system
8. Repeating steps 2–4 to identify, rank and refine the set of statistics to be generated from the surveillance system[27]
9. Repeating steps 2–4 to identify, rank and refine the methods of using surveillance data for public health practice (development and evaluation of prevention and control strategies)
10. Repeating steps 2–4 to identify, rank and refine the methods of timely information dissemination

Further Development of Surveillance Methodology

Development of surveillance methodology is needed to accompany the development of a comprehensive surveillance system in the 21st century. Methodological challenges include (but are not limited to) the following areas: data collection, data analysis, data interpretation, public health practice, information dissemination and computer technology (Table 2).

Discussion

The establishment of a comprehensive, systematic, long-term and population-based epidemiologic surveillance system for early warning and program development, with indicator measures of health quality, risk factors and intervention practices, is very desirable for conducting research and setting health priorities in the 21st century. Such a system could be used to provide trend analysis, risk assessment and early warning of human health changes, to generate hypotheses for epidemiologic research, to produce evidence for program development and to evaluate prevention and control strategies.

It is hoped that a comprehensive surveillance system could issue early warnings to the general population on emerging health problems. New health problems could be predicted based on current health trends, changes in risk factor prevalence, and prevention and control strategies. For example, if smoking prevalence increased, several tobacco-related diseases would be expected to rise. In this regard, the technique of disease modelling is potentially very useful.

Another benefit of a comprehensive surveillance system is to develop and evaluate intervention strategies. If intervention strategies are effective, they should reduce subsequent health problems and risk factor prevalence. For example, if a smoking reduction program (intervention) is successful, it will be accompanied by a reduction in smoking prevalence (risk) and tobacco-related diseases (health).

TABLE 2

Examples of methodological developments needed for a comprehensive surveillance system in the 21st century

1. Data Collection

- Systematic process for indicator selection[28]
- Methodology to convert results from different health surveys with different indicator definitions to a standard and compatible level
- Methodology to increase survey response rates, by population subgroups[29]
- Methodology to collect proxy indicators (e.g. use of surnames to identify ethnic origin[30])
- Incorporation of laboratory data in routine population health surveillance[31,32]
- Development of automatic, laboratory-based, electronic reporting of diseases

2. Data Analysis

- Application of "capture-recapture" methodology[33] to identify missing cases in routine data
- Conditions in which age-standardized techniques can be used for time trend and geographic comparisons
- Development of economic analysis models[34]
- Methodology for multi-level analyses

3. Data Interpretation

- Criteria for rating evidence from epidemiologic studies for evidence-based policy[26]

4. Public Health Practice

- Methodology to utilize surveillance information for the development and evaluation of programs and policies[35]
- Methodology to increase the impact of surveillance activities on society

5. Information Dissemination

- Methodology to alert health professionals and the general public about forthcoming health risks (e.g. risk assessment)[36]
- Innovative and non-traditional methods for information dissemination
- Methods to put our current knowledge of risk assessment and management into perspective so the general public knows what health risks to avoid (e.g. publication of "Handbook of Health Risks") and what healthy activities to pursue (e.g. publication of "Handbook of Healthy Practices")
- Ongoing and timely information dissemination system
- Survey of the general public for their regular and most effective channels of obtaining health information
- Development of summary indicators for health, risk and intervention (e.g. for Canada, Canadian Health Index, Canadian Heart Health Index, Canadian Diet Index) in a way similar to the Consumer Price Index or stock market indices
- Development of 365 health, risk and intervention indicators for reporting to the general public after the evening television news, one indicator a day
- Computer software to calculate probability of risks of selected diseases or overall health outcomes, based on input concerning personal lifestyle, demographics, diet and smoking (e.g. as "hands-on" project to be placed in science museums)

6. Computer Technology

- Automated search and linkage techniques to retrieve information from a vast array of data
- Automated data analysis systems that can produce early warning signals for health and risk factor trends

A comprehensive surveillance system should be based mainly on existing routine data collection, rather than creating a new system from scratch. In other words, planning, prioritization and co-ordination could put existing resources to better use.

By linking various existing databases on health, risk and intervention variables, it is hoped that the full potential (early warning and program development) of a comprehensive surveillance system can be realized. Many of the current surveillance systems collect data only on health outcomes, risk factors or intervention practices, thereby limiting their uses.

An efficient comprehensive surveillance system would not collect millions and millions of pieces of information. A systematic, evidence-based process would narrow down all the information to a list of indicator variables. For example, using the indicator approach, one does not need to measure the concentrations of all the gases in the air to ascertain air quality. Instead, one or two indicator gases, such as carbon dioxide and sulphur dioxide, may suffice.

The process of narrowing down and selecting indicators must be systematic and evidence-based, not hypothesis-driven. The initial steps outlined in this paper are methods for such a systematic process. Many of the current surveillance systems collect data based on the recommendations of those people who are in charge and/or those clients who have the money to "buy in," both unsystematic approaches that can distort the information base of the system.

The long-term nature of a comprehensive surveillance system should be stressed, since this enables the detection of trends. Ground rules and working definitions for a long-term data collection system must be developed. For example, the definition of a smoker should not be changed from year to year. One relevant ground rule could be that, if new knowledge dictates the need for a new definition, the old definition must be continued side by side in the database for a number of years, so as to provide a smooth transition.

A surveillance system for the 21st century should be population-based or based on representative samples of the population. Such widespread data collection would help to reduce the false positive research cycle of sample-based studies described in this paper.

A comprehensive system should evolve and improve with time, especially with respect to data accuracy. For example, record linkage and capture-recapture methodology may be used to improve data quality and to estimate the extent of missing information. Other methodological issues are also suggested in this paper for further work.

This paper is intended to raise questions and stimulate debate on the important topic of epidemiologic surveillance in the 21st century. For example, is additional effort in population-based surveillance needed? Can surveillance tell us as much about etiology as sample-based studies? To answer the many problems we face will require collection of a tremendous amount of data. Can population-based surveillance collect detailed data efficiently?

A reversion to studies of whole populations would obviously eliminate chance error and some types of selection bias (and possibly the discipline called "statistics"), but would it resolve confounding or information bias? Should ecologic correlation studies be used as early models for a future surveillance system? Will all associations with the same strength really have an equal chance of being detected? Since the number of persons exposed and affected will vary, the power to detect associations will vary as well. On the other hand, tests of statistical significance may not be needed, on the grounds that the whole population will be studied.

How will we deal with the vast number of weak associations that will be uncovered by a population-based surveillance system? How would this widespread surveillance data be used? What of the ethical and legal problems posed by the need for privacy of individuals? Finally, who would or should fund the operations of such a comprehensive surveillance system?

Current databases may be inaccurate, problematic and far from able to provide satisfactory information for a comprehensive surveillance system. Scientists must take that very first step now, so that a reasonably useful comprehensive system will be in place by the 21st century.

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Suicide in The Northwest Territories: A Descriptive Review

Sandy Isaacs, Susan Keogh, Cathy Menard and Jamie Hockin

Abstract

The incidence of suicide among the populations of the Northwest Territories (NWT) is notably higher than in the rest of Canada. A comparison of three five-year time periods between 1982 and 1996 reveals an increasing incidence rate, particularly for Nunavut, the eastern half of the NWT, occupied primarily by Inuit people. This is largely attributable to increased use of hanging as opposed to other methods of suicide. A coroner's record review of suicides occurring between 1994 and 1996 demonstrates the preponderance of young males and of Inuit among those who committed suicide, the majority of whom committed suicide in familiar settings, usually their own homes, and often while others were on the premises. Thirty-six percent of those who committed suicide had experienced a recent family or relationship breakup, and twenty-one percent were facing criminal proceedings. Understanding the impact of these and other reported circumstances on the imminent risk of suicide requires further investigation.

Key words: *aboriginal health; intentional injuries; Northwest Territories; suicide*

Introduction

Suicide among aboriginal groups in Canada has been reported to be two to four times more frequent than in the population at large.[1,2] In the Northwest Territories (NWT), where aboriginal populations represent the majority, considerable attention has focused on an apparent increase in the occurrence of suicide in a number of communities. In 1992 the annual age-standardized suicide rate for the NWT was estimated at 23 per 100,000 population compared to 13 per 100,000 for Canada as a whole.[1]

In the spring of 1997, the Department of Health and Social Services of the Government of the NWT (GNWT) invited the Field Epidemiology Training Program at Health Canada's Laboratory Centre for Disease Control to collaborate in a review of existing suicide mortality data with the following objectives.

- To identify subgroups of the population in the NWT who are most at risk of suicide
- To describe the circumstances surrounding the deaths of people in the NWT who have committed suicide

Material and Methods

For this report, suicides are defined as deaths due to self-inflicted injury with the intent of causing death. Two approaches were taken to achieve the study objectives: an analysis of a suicide database of suicide events recorded since 1981 and a review and summary of coroner's reports on suicide cases for the period 1994–1996.

Suicide Database Review

The suicide database, containing 343 suicide events recorded between 1981 and 1996, was created by the Social Services Branch of the GNWT (now the Department of Health and Social Services) through cross-referencing of data from the coroner, health services and vital statistics. Events from this source were used to calculate suicide rates for various population

Author References

Sandy Isaacs and Jamie Hockin, Field Epidemiology Training Program, Laboratory Centre for Disease Control, Health Canada, Ottawa, Ontario
Susan Keogh, Department of Health and Social Services, Government of the Northwest Territories
Cathy Menard, Office of the Chief Coroner, Northwest Territories

Correspondence: Sandy Isaacs, Epidemiologist, Wellington-Dufferin-Guelph Health Unit, 125 Delhi Street, Guelph, Ontario N1E 4J5; Fax: (519) 836-7215

subgroups of the Northwest Territories and for different time periods.

Average annual rates were calculated by age, sex, ethnicity and region for the period 1986–1996 (11-year period). The population census for 1991 (mid-year for the period) was used as the denominator. For exploring changes over time, rates were calculated for three five-year periods, using mid-year population estimates as the denominators.

We calculated direct age-standardized suicide rates using the 1991 Canadian census population for Eastern NWT (Nunavut) and Western NWT, to allow for comparison with the Canadian experience. Otherwise, crude rates were used for both time and geographic comparisons within the NWT. Indirect age-standardized rates, originally calculated using NWT rates as the standard, were not noticeably different from the crude rates used.

Coroner's Record Review

The coroner's records of all 78 individuals who committed suicide during the three-year period 1994–1996 were manually reviewed and information was extracted using a standard data retrieval form. Information was retrieved on demographics (age, sex, ethnicity, employment, marital status), cause of death, toxicology findings, events and behaviours immediately preceding death and mental health history, where available.

Results of Suicide Database Review

Demographic Distributions

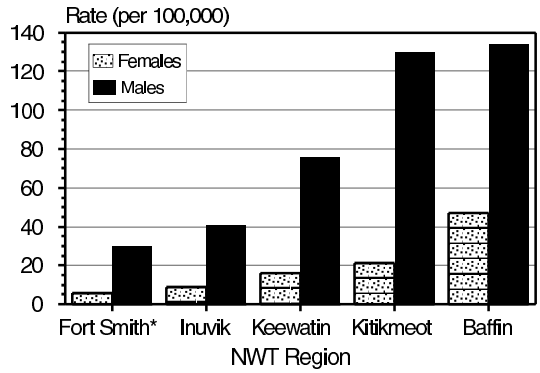
Over the 11 years from 1986 to 1996, there were 261 deaths due to suicide in the NWT. The average annual rate of suicide for the NWT was 41.3 per 100,000 population. The direct age-standardized rate was 36.7 per 100,000. The crude suicide rate for Nunavut (77.9 per 100,000) was almost four times the crude rate for Western NWT (19.9 per 100,000). Direct age-standardized rates were 67.4 per 100,000 and 18.9 per 100,000, respectively.

On a regional basis, the further east the region is located, the higher the crude rate of suicide for both males and females (Figure 1). The higher rate of suicide for Nunavut compared to Western NWT is maintained across age and sex groups. The average annual suicide rate for males is 119 per 100,000 in Nunavut and 34 per 100,000 in Western NWT, while the respective rates for females are 32 and 17 per 100,000. Those aged 15–29 are at highest risk (Figure 2).

In our calculations of annual suicide rates by ethnic group, the highest rate occured among the Inuit, at 79 per 100,000, compared with 29 per 100,000 for the Dene and 15 per 100,000 for all other ethnic groups in the NWT, primarily non-aboriginal.

FIGURE 1

Average annual suicide rates (per 100,000) by NWT region, 1986-1996



* Fort Smith refers to the region as defined prior to 1988 and includes the 1997 regional health board jurisdictions of Yellowknife, Ft Smith and Ft Simpson.

FIGURE 2

Average annual suicide rates (per 100,000) by age group, Western NWT and Nunavut, 1986-1996

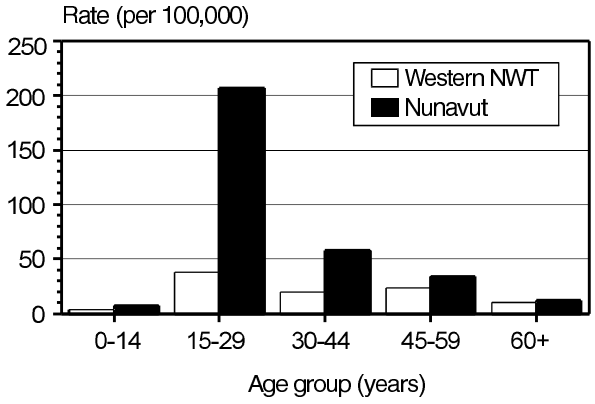
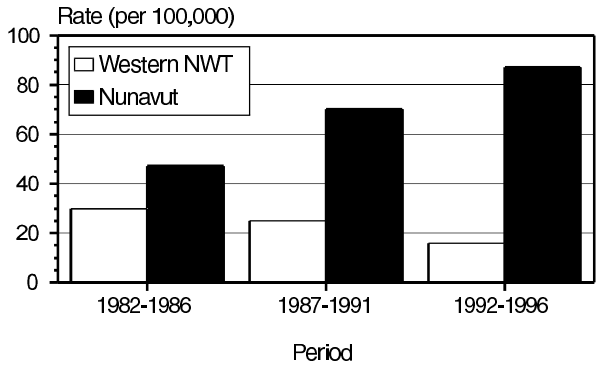


FIGURE 3

Average annual suicide rates (per 100,000) by 5-year period, Western NWT and Nunavut, 1982-1996



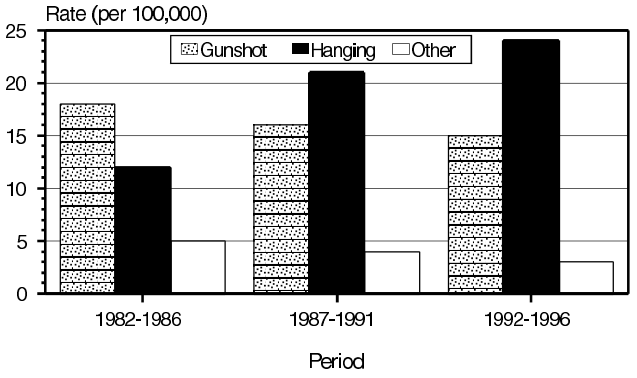
Trends

Figure 3 illustrates an increase in the suicide rate for Nunavut over three five-year periods from 1982 to 1996. The average annual rate for the most recent period (1992–1996) is almost twice that of the first period (1982–1986). Conversely, the rate of suicide for Western NWT declined over the same time span.

For the NWT as a whole, the rate of suicide by hanging doubled over the three time periods while rates by other methods showed a moderate decline (Figure 4). In Nunavut alone, suicide by hanging jumped from 27 per 100,000 for the period 1982–1986 to 57 per 100,000 for the period 1992–1996; suicide by firearms also rose from 19 to 28 per 100,000, a 50% increase.

FIGURE 4

Annual method-specific suicide rates (per 100,000) by 5-year period, Northwest Territories, 1982-1996



Results of Coroner's Record Review

Demographic Profile

Of the 78 cases of suicide reviewed for the period 1994–1996 using coroner's reports, 61 (78%) were male, 56 (73%) were between 15 and 29 years of age, 68 (87%) were Inuit, 53 (68%) were single and never married, 41 (53%) were unemployed and 60 (77%) lived with family members.

Time of Occurrence

Suicide events were almost equally distributed across the three years with 26 in 1994, 24 in 1995 and 28 in 1996. A moderate peaking of events (26/78 or 33%) occurred during the third quarter of the year (summer), July to September. Most suicide acts (actions that led to death) were estimated to have occurred between evening (10 pm) and morning (10 am) [44/71 or 62%]. The length of time between the act and discovery averaged 8 hours, with a median of 2 hours, and ranged between 0 and 108 hours (*n*=76) . The peak 4-hour period for committing the suicide act was between midnight and 4 am (20/71 or 28%).

Place of Occurrence

Thirteen suicides (17%) occurred among residents of Western NWT and sixty-five (83%) among residents of Nunavut. Among the three regions of Nunavut, Baffin Region had the highest number of suicides (36), representing 46% of all suicides in the NWT between 1994 and 1996. The suicide occurred most often near or in the home of the deceased (58/78 or 74%). Twenty-four suicides (31%) took place by hanging in a bedroom closet.

Method of Suicide

Our review of coroner's cases revealed hanging as the most frequent method of suicide used by both sexes (13 or 77% of females, and 36 or 59% of males). Among the 68 Inuit who committed suicide, 46 (68%) died by hanging and 20 (29%) died from a gunshot wound. Of the 10 non-Inuit suicide cases, 7 (70%) died from a gunshot.

Circumstances Surrounding the Suicide

The events most frequently identified as coincident with the suicide were a family or relationship breakup in the last year (28 or 36% of cases) or a pending criminal proceeding (16 or 21%). Ten of the sixteen individuals with pending criminal proceedings were facing charges of sexual or other assault.

Efforts to resuscitate the suicide victim occurred in 30 cases (39%). These resuscitation efforts occurred more often if the method of suicide was hanging (24/49 or 49%) as opposed to the use of a firearm (4/27 or 15%), or if the individual was discovered within the first hour following the suicide act (21/31 or 68% vs 7/35 or 16%). Attempts were made to resuscitate all 16 individuals who used hanging and who were discovered within the hour following their suicide act.

Alcohol and drug consumption

Blood alcohol results were available on 61 of the 78 cases (78%). Results were not available on others primarily because of an inability to take adequate samples of body fluids (blood or urine) from individuals discovered some time after death. Of those sampled, 35 (57%) had no alcohol detected in their blood, and another 6 (10%) had alcohol levels below the legal limit for impairment (17 mmol/L). Those considered impaired at the time of death numbered 20 (33%). Adults 25 years and older were more often intoxicated at the time of death than were youths aged 24 or less (12 of 24, or 50% vs 8 of 37, or 22%).

Drug screens based on urinalysis were available for 37 cases (47%) . Of these, 8 tested positive for canabinoids. No other illicit drugs were detected.

Events 24 hours preceding death

Almost all of the suicide victims (73 or 94%) were reported as being with others during the 24 hours prior to their death. Forty-six suicides (59%) were reported as occuring while others were on the same premises. In 68 (88%) of the 78 cases, one or more distressed or unusual behaviours were noted during the 24 hours before death, including 21 cases (31%) who made a statement of suicide intent. Attempts to assist the individual with his or her distressed state were reported in 14 cases (18%).

Social and mental health history

Thirty-one of the suicide victims (40%) had a history of previous suicide attempts, and forty-four cases (56%) were reported to have made a statement of suicide intent at some time in their past. More than one quarter of the victims (27%) had lost at least one friend or relative to suicide. The records showed that 22 of the suicide victims (28%) had sought help for social or mental health problems, 10 (13%) had seen a professional care-giver in the week prior to the suicide and 50 (64%) had a history of emotional distress or depression. Thirty-six cases (46%) had a reported history of alcohol abuse, and 22 (28%) had a history of drug abuse. Nineteen suicide cases (24%) had a criminal and/or other conviction on record. All 16 individuals with criminal convictions were males (26% of the males).

Discussion and Conclusions

The upward trend in the suicide rate among residents of Nunavut over the last 15 years is striking, as is the difference in rates between Nunavut and Western NWT. This information implies a rising risk of suicide among the Inuit of Nunavut, who make up 85% of the population in this region. From 1986 to 1996, the direct age-standardized rate for Nunavut, was 67.4 per 100,000 persons, five times the national rate reported in 1992 (13 per 100,000). The age-standardized rate for the NWT as a whole was 36.7 per 100,000, almost three times the national rate.

In both this review and another one involving the aboriginal people of British Columbia,[3] homes were not safe havens for individuals at risk of suicide. Opportunities exist in the home; in the NWT, hanging was the suicide method most often used and is the primary method of recent years. The predominance of hanging, specifically among the Inuit, differs from other suicide studies in which the use of firearms ranks first.[1] The most frequent method of suicide used by Manitoba aboriginals was also identified as hanging.[4]

This report does not offer an explanation as to why suicide rates in the NWT are so high. We do know that, as with other populations in Canada including aboriginal groups, those most at risk of suicide are males and persons 15–29 years of age.[1,3,4] In addition, we observed some of the more prominent characteristics and circumstances of the individuals who committed suicide in this NWT population: 36% of the people who committed suicide between 1994 and 1996 had experienced a recent relationship breakup and 21% were facing criminal proceedings. Also in our study, alcohol intoxication at the time of suicide was observed in 33% of the cases. This differs from two other Canadian suicide studies involving aboriginal groups, where alcohol intoxication at time of death was noted in 60% and 65% of cases.[3,4] In a study of Alaskan natives, 79% of suicide cases involved alcohol.[5]

As reported in the literature, the causes of suicide are complex.[6,7] There is a need to distinguish between the historic experiences and general characteristics of individuals that place them at higher risk of suicide (distal risk factors) and the more immediate risk factors or triggers (proximal risk factors), such as a family breakup or other stressful life event.[8] In the North, distal risk factors may be systemic to the life experience of many communities—unemployment, poverty, poor education, lack of opportunity and loss of cultural identity.[1,7,9] Dealing with the distal issues at a societal level may help to reduce the number of people vulnerable to committing suicide in the long term.

Of immediate need are tools, methodologies and training opportunities that will help to identify currently vulnerable individuals, the situations or conditions that heighten their vulnerability at any one time and their risk behaviours, so that professionals as well as immediate friends and family can be alerted to the imminent danger of suicide.[1,3] Community members need to be empowered to act with the appropriate resources—within themselves or through access to emergency services—in order to avert future tragedies.

Limitations

The coroner's files consisted of the investigating RCMP officers' and coroner's written documentation of the behaviours and events surrounding each suicide. These were based on the accounts of other individuals who knew the deceased, primarily relatives and friends. Reports concerning the 24 hours preceding the suicide were the most detailed and, because of the immediacy to the event, the most reliable. However, the thoroughness of each investigation and/or completeness of the coroner's report did vary by case. Consequently, behaviours and events captured in this review are likely underreported.

Suicide rates for the Northwest Territories can vary dramatically from one year to the next due to the small size of the population (65,000) and any subgroup thereof. We tried to compensate for this instability by combining years of data in order to calculate rates and then estimate average annual rates. By inference, there is a need to continue long-term surveillance of the suicide phenomenon in Nunavut and Western NWT in order to detect true shifts in trends and the impact of any new or enhanced interventions that may be introduced.

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Monograph Series on Aging-related Diseases: XI. Glaucoma

Robin Elolia and Julie Stokes

Abstract

In Canada, glaucoma is the second leading cause of blindness in people aged 50 and over, with primary open-angle glaucoma (POAG) accounting for 90% of all cases. Prevalence of POAG increases with age, and the condition is found more commonly among blacks than whites. Elevated intraocular pressure is an important risk factor for the disease; however, its positive predictive value for the presence of disease is poor. Prevalence of primary angle-closure glaucoma also increases with age, occurs more frequently among the Inuit and Asians, and has been reported to be more common among women. There are various diagnostic methods used to determine the presence or absence of glaucoma, but none can effectively identify the disease in its early stages unless routine screening is conducted. Current treatment of glaucoma is aimed at lowering intraocular pressure, which usually, but not always, stops disease progression.

***Key words**: diagnosis; glaucoma; morbidity; risk factors; screening; treatment*

Nature and Classification

Glaucoma, a major cause of impaired vision and blindness, is really a group of ocular disorders that are responsible for excavation and atrophy of the optic disc and gradual loss of the visual field. If glaucoma is left untreated or if diagnosis is made at an advanced stage of disease, blindness may result. Defining, screening for and treating the early stages of this disease continue to be a challenge.[1]

There are two broad types of glaucoma: open-angle and angle-closure. Each of these can be divided into either primary or secondary forms. When the cause of the glaucoma is not known, it is termed *primary*; it is known as *secondary* when the condition can be traced back to another cause.[2] Recent prevalence estimates conclude that the glaucomas are the second leading cause of blindness worldwide, responsible for 6.4 million blind persons,[3] and the second leading cause of blindness in Canadians aged 50 and over.[4] Primary open-angle glaucoma (POAG) accounts for 90% of all cases.[5] Other types include primary angle-closure glaucoma (PACG), secondary glaucoma and congenital glaucoma. Discussion here will focus on POAG and, to a lesser extent, on PACG.

To understand the tests used in the diagnosis of glaucoma, it is helpful to review the morphological components involved. The front chamber of the eye is made up of the cornea, iris, pupil and lens, and it is filled with a fluid called *aqueous*. Aqueous is constantly being produced to feed the lens and cornea,[6] and usually flows through the trabecular meshwork and the canals of Schlemm to reach its final point, a vein.[1] When the flow is blocked, pressure builds up in the eye and leads to elevated intraocular pressure (IOP).

Elevated IOP causes optic nerve cupping (either directly or indirectly),[7] which in turn causes damage and eventual death to the cells, and permanent loss of vision. The optic nerve head consists of many axons (nerve fibres) of ganglionic cells in the retina collectively leaving the eye. At the point of leaving, the optic nerve appears round and is referred to as the optic *disc*. In its

Author References

Robin Elolia and Julie Stokes, Division of Aging and Seniors, Population Health Directorate, Health Promotion and Programs Branch, Health Canada

Correspondence: Julie Stokes, LCDC Building, Health Canada, Tunney's Pasture, AL: 0602E2, Ottawa, Ontario K1A 0L2

centre is the physiologic cup, a small indentation resulting from the transmission of the central retinal artery and vein. A normal ratio of cup-to-disc diameters is 0.3 (i.e. the cup is about 1/3 that of the disc).[2,8] The cup has been described as a hole in the centre of a doughnut, where the doughnut is the neuroretinal rim (the area between the cup and the margin of the disc).[9] In glaucoma, damaged nerve fibres eat away at the neuroretinal rim, resulting in cupping of the optic nerve.

POAG is the most common form of glaucoma and is only diagnosed as such once the other forms of glaucoma have been ruled out. Its middle-aged onset (over 40 years)[10,11] is insidious and may be asymptomatic up to the point where a person is blind.[11] In POAG, the aqueous cannot flow through the trabecular meshwork due to a blockage or malfunction of the eye's drainage system. This blockage causes IOP to increase. Open-angle glaucoma in which the IOP falls within a range of levels that is non-threatening to the functioning of the retina and optic nerve is termed *low tension glaucoma*.[2] Ocular hypertension occurs when there is no detectable change in vision and no damage to the structure of the eye, but pressure is elevated. Although individuals with ocular hypertension are at risk of developing glaucoma, not all do.[7]

In PACG, the peripheral part of the iris bunches up against the trabecular meshwork and prevents drainage of aqueous from the anterior chamber, resulting in raised IOP. Blockage usually results from one of two mechanisms: (1) pupillary block, where a buildup of aqueous that did not flow through the pupil from the posterior chamber to the anterior chamber causes the iris to push forward, eventually occluding any drainage through the trabecular meshwork, or (2) direct blockage by iris tissue, which results in a shallow anterior chamber. Whether or not an anterior chamber angle is going to occlude is largely influenced by the angle width and the depth of the anterior chamber itself. Onset of PACG is usually rapid when a sudden increase in IOP causes asymmetrical pain and blurred vision. In an acute attack, levels of IOP can reach as high as 70 mmHg,[8] but chronic PACG also exists with transient increases in IOP up to the point where the angle is finally closed.[2] Although PACG occurs less frequently than POAG, it becomes more common as age increases.[12]

Blindness

Both primary glaucomas can be asymptomatic[13] up to their advanced stages.[14] However, POAG in particular, with its insidious onset, presents a major public health problem since considerable loss of the visual field can go unnoticed in a patient whose central acuity is still good.[14] In an attempt to understand why some people are blinded by glaucoma, Grant and Burke[15] retrospectively analyzed 93 patients in a Massachusetts eye clinic. They found that one third of these patients did not seek treatment until they had gone legally blind, demonstrating how loss of the visual field occurs before subjective awareness of a loss of vision. The majority actually had reported experiencing symptoms but they did not realize the significance. About one half of the study subjects were not blind when initially diagnosed, but later became blind, despite treatment. A portion of treatment failure could be explained by non-compliance.

A second part of Grant and Burke's study reviewed 200 records of sighted glaucoma patients who had been followed for 20–40 years. A comparison of the two glaucomatous groups (blind and sighted) suggested that blindness is more likely to occur if visual field defects exist in eyes starting treatment as opposed to the presence of disc cupping in eyes starting treatment (i.e. later stage of disease vs earlier stage of disease).[15] The results of this study were consistent with others,[11,14] confirming that early discovery and treatment of glaucoma in patients can maintain vision for years.

The severity of vision impairment varies in different populations, as demonstrated by the prevalence of blindness among glaucoma patients. A prevalence study conducted in Ireland found 7.3% of subjects with glaucoma to be blind,[16] while similar surveys in Mongolia and South Africa yielded prevalences of approximately 18%.[17] The discrepancy likely reflects the lack of detection and treatment in the developing world.

In the early 1980s, Grant and Burke[15] showed that the proportion of blindness among patients of African descent was considerably higher than the proportion of blindness in the general population of the clinic undergoing treatment. From this, they inferred that African-Americans were at higher risk for glaucoma blindness. In the early 1990s, Sommer et al.[18] found the age-adjusted prevalence for blacks (3.74 per 1000) to be statistically significantly different from that for whites (0.7 per 1000). It has since been determined that glaucoma is the leading cause of blindness among blacks[19,20] and that the risk of glaucoma blindness is eight times higher among blacks than whites.[21]

Primary Open-angle Glaucoma

Prevalence

Clinic and mass screening protocols initially relied on tonometric readings of IOP greater than or equal to 21 mmHg to be the deciding factor for a complete ophthalmologic assessment. It became certain that prevalence was underestimated by this method when rates were calculated from population studies screening for POAG that used a comprehensive set of tests, most often excluding IOP in the diagnostic criteria.

Table 1 presents some population studies of POAG prevalence.[16,17,22–33] The validity of the study results is influenced by the sampling design, the sensitivities and specificities of the screening methods and the diagnostic criteria. Examination of every subject's full visual field

TABLE 1
Cross-sectional studies of primary open-angle glaucoma

Study (Year)	Age group	*N*	Screening methods	Diagnostic criteria	Visual field testing as screening method (%)	No of cases	Crude prevalence
Framingham, MA (1973–1975)[22]	52–85	2433	H, T, O	GVFD	Not stated	28	1.4
Roscommon, Ireland (1990)[16]	≥50	2186	H, T, G, O, P	GVFD, IOP, C/D	55.8	41	1.9
Casteldaccia, Italy[23] (before 1992)	≥40	1062	H, T, SL, O	GVFD	Not stated	13	1.2
Ponza, Italy[24] (1986)	≥40	1034	H, O, SL, T, G	GVFD and one of IOP, C/D	55.0	26	2.5
Beaver Dam, WI[25] (1988–1990)	43–84	4926	P, SL, T, H, O	2 abnormalities of GVFD, IOP, C/D, H, S	100.0	104	2.1
Baltimore, MD[26–28] (1985–1988)	≥40 White Black	5308 2913 2395	P, T, SL, G, H, O	GVFD, ONHD or NFLD for those not receiving perimetry	100.0	132 32 100	2.5 1.1 4.2
Barbados[29] (1988–1992)	40–84, AC	4631	P, T, SL, O, Fundus Photo	GVFD + C/D≥0.7 or neuroretinal rim notching	95.0	309	6.7
St. Lucia[30]	≥30	1679	T, O, P every 3rd person	GVFD or IOP≥ 30 mmHg, C/D≥0.7 C/D asymmetry≥0.2	31.0	147	8.8
Japan[31] (1988–1989)	≥40	8126	T, SL, G, Fundus Photo	IOP≥21 mmHg, GVFD, NFLD	0.0	213	2.6
Mongolia[17] (1995)	≥40	942	P, SL, G	GVFD + ONHD	100.0	5	0.5
Mamre, South Africa[32] (1992)	≥40	987	SL, G, O, T, P	GVFD + ONHD	Not stated	15	1.5
Australia[33] (1992–1994)	≥49	3654	T, P, G	H, GVFD + optic thinning and C/D	Not stated	108	3.0

AC = African-Caribbean
C/D = Cup:Disc ratio
G = Gonioscopy
GVFD = Glaucomatous visual field defects
H = History
IOP = Intraocular pressure
NFLD = Nerve fibre layer defects
O = Ophthalmologic exam
ONHD = Optic nerve head defects
P = Perimetry
S = Surgery
SL = Slit-lamp exam
T = Tonometry

and optic nerve would have been ideal; however, cost and time were prohibitive. Nonetheless, many of the studies were ambitious and used perimeters to test a portion of the visual field as part of the initial screening. Thus, each study employed different screening protocols, different perimeters and different diagnostic criteria. Together, each combination resulted in producing different balances of sensitivities and specificities that may have influenced their outcomes.[26]

One factor affecting the variation in prevalence of POAG may be differences in the race of the population studied. Crude prevalence rates ranged from 0.5%[23] in Northern Mongolia to 8.8%[30] in St. Lucia, West Indies. The rates from studies of black populations are clearly higher than those from studies of white and Asian populations.

The definition of glaucoma used may also play a role in the differences among prevalence results. Both studies in the West Indies displayed high prevalence. While the prevalence in the St. Lucia study was remarkably high (8.8%) even though only 31% of the study subjects completed visual field testing,[30] the Barbados study[29] determined a prevalence of 6.7%, with 95% of those surveyed completing visual field testing as an initial screening tool. This lower prevalence may reflect the use of a stricter definition of glaucoma (visual field defects plus optic disc damage). The Barbados study detected the largest number of glaucoma cases (309) in a population study, and the prevalence would likely have been higher if the diagnostic criteria had been less rigorous. In addition, the Sicilian rate in Casteldaccia, Italy,[23] likely underestimated the true population prevalence since an initial screening, with tonometry readings of less than 21 mmHg and no other ocular

finding, did not allow new cases with low tension glaucoma to be identified.

Low tension glaucoma is best detected with the use of multiple indicators and, above all, a high proportion of visual field testing. From the studies presented in Table 1, 24–78% of individuals with POAG had low tension glaucoma (IOP less than 21 or 22 mmHg). It is interesting that Mason et al.[30] described a high frequency of low tension glaucoma (53 cases) in St. Lucia, despite the low rate of visual field testing (31%). Also noteworthy was the very high frequency of low tension glaucoma cases (166) in the Japanese National Study[31] as compared to the number of cases of POAG with elevated IOP (47). Ocular hypertension was also low among the Japanese and did not increase with age.

Prevalence rates increase with age, peaking after age 70 (Table 2).[16,23,25,27,29–31,34] In all the studies but the one in St. Lucia, more than 50% of the POAG cases occurred in persons aged 70 and older. While the aging factor applies to all races, the most dramatic increases with age were seen in St. Lucia[30] and Barbados.[29] Of the three studies examining people of African descent, the Barbados study[29] reported the highest rates in the upper age groups: 14.8% at ages 70–79 and 23.2% at ages 80+ (almost 17 times more common than in the 40–49 age group). The highest frequency in a population of European descent (4.7%) was observed among those aged 75 and over in the Beaver Dam Eye Study.[25] In the Framingham Eye Study,[34] one of the definitions of glaucomatous visual field defects was the existence of blind spot enlargement in the absence of other visual field defects characteristic of glaucoma. This would explain why the prevalence observed among the 75–85-year-olds was higher.

Most recent studies have shown that a person's sex has no effect[16,25,28–31,34] on the prevalence of glaucoma. The one exception was the study by Leske et al.,[35] where POAG occurred more than 1.5 times more frequently among men than women (odds ratio [OR] = 1.66, 95% confidence interval [CI] = 1.24–2.24).

Risk Factors

Race

There is considerable evidence that POAG is much more common among blacks than whites, and some researchers have even suggested that the disease is more severe among blacks.[15,21,36,37] Several studies have indicated that POAG is more prevalent among blacks,[9,10,15,28,29,36] and some have found a higher frequency of glaucoma blindness among blacks.[18,19,21,36] As well, blacks seem to develop POAG at a younger age than whites (Table 2). In St. Lucia,[30] a high proportion of young subjects had POAG at a detectable level: 4.0% prevalence among 30–39-year-olds and 7.3% among 40–49-year-olds. Higher rates among younger age groups were also observed in Barbados[29] and among

TABLE 2

Age-specific prevalence of primary open-angle glaucoma from eight population studies

Study	Age group	Prevalence (%)
Framingham, MA[34] (all races)	52–64	1.4
	65–74	5.1
	75–85	7.2
	Total	**3.3**
Beaver Dam, WI[25]	43–65	1.0
	55–64	1.7
	65–74	2.7
	75+	4.7
	Total	**2.1**
Roscommon, Ireland[16]	50–59	0.7
	60–69	1.8
	70–79	3.2
	80+	3.1
	Total	**1.9**
Casteldaccia, Italy[23]	40–59	0.4
	50–59	0.3
	60–69	1.4
	70+	3.6
	Total	**1.2**
Baltimore, MD[27]	**European**	
	40–49	0.9
	50–59	0.4
	60–69	0.9
	70–79	2.9
	80+	2.2
	Total	**1.3**
	African–American	
	40–49	1.2
	50–59	4.1
	60–69	5.5
	70–79	9.2
	80+	11.3
	Total	**4.7**
Barbados[29]	40–49	1.4
	50–59	4.1
	60–69	6.7
	70–79	14.8
	80+	23.2
	Total	**6.8**
St. Lucia[30]	30–39	4.0
	40–49	7.3
	50–59	8.7
	60–69	15.2
	70+	9.5
	Total	**8.8**
Japan[31]	30–49	1.0
	50–69	2.6
	70+	5.3
	Total	**2.5**

African-Americans in Baltimore.[27] The reasons for the apparently increased risk of glaucoma in black populations is not clear; however, it may be related to the fact that they have somewhat higher levels of IOP compared to white populations.[37–42]

Family history

A study by Rosenthal and Perkins[43] found that roughly 9% of subjects with a family history of POAG developed glaucoma. This finding is higher than any other reported in recent cross-sectional studies, and confirms the findings from Perkins' earlier clinic-based investigation of relatives of patients.[44] Of the 190 people screened who had relatives with POAG, 11 individuals (5.8%) had POAG, including 1 case of low tension glaucoma. Those screened included children.

In a Canadian study, Morgan and Drance reported that glaucoma patients were 7.5 times more likely to have a mother who had a serious eye disease than were controls (relative risk [RR] = 7.5, $p<0.005$).[45] A more recent investigation in the United States[46] found that 50% of patients with POAG and 45% of patients with ocular hypertension had a family history of the disease. Uhm and Shin[47] found that having a positive family history was an important risk factor for POAG but its contribution to risk was more pronounced for ocular hypertension (OR = 2.4, 95% CI = 1.65–3.49).

In England, a hospital-based screening service invited siblings with a positive family history of POAG to attend the clinic for an ophthalmologic assessment. The prevalence of POAG among siblings of POAG patients was 10 times greater than that of controls or the general population.[48]

The proportion of cases with a positive family history may be inflated in the previous studies since most were clinic-based and subject to different selection biases. The most important were recall bias for a positive family history[49] and the use of IOP and cup-to-disc ratio, two genetically determined characteristics[50,51] used in diagnostic criteria.

Most recent cross-sectional studies confirm the association of POAG and a family history of the disease. Statistically significant odds ratios in any first-degree relative range from 2.43 to 3.08.[35,49,52] Men with a family history of POAG have almost eight times the risk (OR = 7.88, 95% CI = 4.07–15.23) and the sex-history interaction is more significant for males than for females (OR = 2.48, 95% CI = 1.48–4.23).[35] Stronger associations of POAG have been found to exist with a history of glaucoma in siblings (age- and race-adjusted OR = 3.69, 95% CI = 2.10–6.48) than in parents (OR = 2.17, 95% CI = 1.07–4.41), and race accentuated this risk further; the OR for an African-American with positive history in a sibling was 4.37 (95% CI = 2.28–8.36).[49]

While it is obvious that family history plays a role in POAG, the exact mode of inheritance remains unclear. Recently, the GLC1A gene[53–55] and others[54] surfaced as potential risk factors for POAG development.[53] The reader is referred to an up-to-date review on the genetics of glaucoma[56] for further information.

Non-ocular factors

The vascular theory explaining the etiology of glaucoma has prompted considerable interest in risk factors that are vascular in nature. It was hoped that the identification of some of these might help to explain the discrepant outcomes of low and high IOPs.[57]

Diabetes

Zeiter et al.[58] demonstrated a vascular association between glaucoma in people with diabetes and in those without diabetes by comparing the patterns of visual field defects. Diabetic patients with POAG experienced field loss in the inferior half of the visual field in contrast to non-diabetic glaucoma patients, whose field defects were more often in the superior half. The researchers also found that diabetic patients developed such defects more often than patients without diabetes. It was already known that visual field defects develop more commonly in the superior half of the visual field during the early and middle stages of disease.[59] The authors postulated that the vascular component of diabetes may render a patient with POAG more susceptible to visual field loss at lower IOPs than glaucoma patients who are not diabetic.[58]

Results from many earlier investigations of diabetes as a risk factor have been inconsistent. In some studies, the risk of POAG was between 3 and 4.5 times greater for people with diabetes,[57,60,61] while others found no association at all.[22,62,63]

More recent studies also have been inconclusive. Findings from the Baltimore study[27] and other population studies[64–66] suggested no association between diabetes and glaucoma. This was true for age- and race-adjusted ORs and for both types of diabetes. As well, despite the large sample size and high prevalence of diabetes, an association was not determined from the Barbados data.[35] On the other hand, frequency of glaucoma among diabetic patients (4.2%) was significantly higher than among non-diabetic individuals (2.0%, $p = 0.004$) in the Beaver Dam Eye Study,[67] with more intense effects in the older age groups (65–74: prevalence = 6.0%, $p = 0.01$). The Blue Mountains Eye Study[68] also reported a significantly increased prevalence of glaucoma among those with diabetes (age- and sex-adjusted OR = 2.12, 95% CI = 1.18–3.79).

Both Zeiter et al.[58] and Klein et al.[67] suggested that the increased risk for POAG among diabetic patients might be due to heightened susceptibility to optic nerve damage resulting from raised IOP. Becker supported this

suggestion because he found diabetic glaucoma patients to be at greater risk for nerve fibre layer damage with subsequent visual field loss at a lower IOP compared with non-diabetic glaucoma patients.[69]

While an association between raised intraocular pressure and diabetes would support the theory that diabetes may indirectly increase the risk for POAG through its bearing on IOP, no study to date has shown this.[27,70,71]

Blood pressure

In the past, both high and low blood pressures have been associated with glaucomatous visual field defects. Hypertension may cause small vessel disease and reduced blood flow to the optic nerve, resulting in ischemia and an increased risk of visual field loss.[72] Evidence from the Health and Nutrition Examination Survey of 1971–1974 demonstrated how elevated blood pressure levels indirectly affected the filtration process of aqueous.[38,73] Normal, continued production of the fluid would increase the IOP and the potential for glaucomatous visual field defects.

Findings from earlier epidemiologic studies suggested that the increased risk of POAG associated with hypertension[38,45,60,61] might be spurious. In more recent investigations, such as the Baltimore,[74] Barbados[35] and Casteldaccia[66] studies, evidence of a relationship between POAG and blood pressure (BP) could not be found. However, a low diastolic perfusion pressure (diastolic BP–IOP difference) was associated with POAG in Barbados (OR = 3.29, 95% CI = 2.06–5.28),[35] Baltimore (OR = 6.22, 95% CI = 2.15–17.94)[74] and Long Island (OR = 11.99, 95% CI = 4.02–35.76).[52] The Long Island Glaucoma Study also found low systolic perfusion pressure to be significantly associated with POAG (OR = 6.00, 95% CI = 1.84–19.59).[52] Reynolds[61] found that systolic BP-to-IOP ratios of less than 5.75 appeared significantly more often in glaucoma cases than in controls (RR = 30.5, $p<0.001$).

Hypotension due to antihypertensive treatment or a hypotensive crisis has been linked with increased risk of glaucoma.[45,75] Results from two case-control studies showed that glaucoma patients had used antihypertensive treatment more often than ocular hypertensives or controls.[45,61] Despite this, the literature did not report an increased risk of visual field loss associated with the use of antihypertensive treatment.[10,52]

Migraine

The relationship between migraine and glaucoma remains unclear. Since migraine headaches are vascular in nature, Phelps and Corbett[76] speculated that they might increase the likelihood of developing low tension glaucoma. Their case-control study found a higher prevalence of headache in patients with low tension glaucoma (64%) than in controls (59%), with the difference being statistically significant ($p = 0.04$). Klein et al.[77] and Usui et al.[78] investigated the relationship of migraine to POAG and low tension glaucoma in their population and clinic-based investigations; however, neither found any evidence of a relationship between POAG or low tension glaucoma and migraine headache.

Alcohol and smoking

While a high intake of alcohol has been positively associated with glaucoma,[22,57] the opposite has also been found to be true. In a US case-control study comparing ocular hypertensive and normotensive patients, abstinence from alcohol was associated with ocular hypertension (OR = 3.8, 95% CI = 1.4–10.4).[39] Earlier case-control studies showed smoking to be a risk factor for both POAG (rate ratio = 2.9, 95% CI = 1.3–6.8)[60] and raised IOP.[45] Current findings, however, do not concur: relationships between alcohol, smoking and open-angle glaucoma were not found in the Beaver Dam,[79] Barbados[35] or Casteldaccia[66] eye studies.

Corticosteroids

The use of topical or systemic corticosteroids has been reported to increase the risk of persistent ocular hypertension and glaucoma.[80,81] A more recent case-control study[82] found an association between long-term high doses of inhaled corticosteroids and POAG. Cross-sectional data have shown steroid use to both significantly increase the risk of POAG (OR = 7.79, 95% CI = 2.73–22.21) and to have no effect whatsoever.[35] Some researchers refer to corticosteroid-induced glaucoma as one of the secondary glaucomas.[8]

Ocular factors

Intraocular pressure

According to Rosenberg,[20] "elevated IOP is the most consistent risk factor for the development of progressive optic nerve damage." Others also have found an association between IOP and POAG.[29,35,83] The risk for glaucoma is 7–22 times greater in ocular hypertensives than normotensives,[84] and pressure closer to 30 mmHg accentuates this risk.[85] While IOP may be an important risk factor, its positive predictive value for the presence of disease is poor.[20] Between 24 and 78% of open-angle cases were classified as low or normal tension glaucoma in recent epidemiologic investigations.[16,23,25,30,31]

A level of IOP corresponding to glaucomatous visual field defects has not been defined; the 21 mmHg cut-off is two standard deviations above the population mean[14] and does not correspond to a point at which visual field defects occur. In one study, the mean IOPs for the normal and glaucomatous populations were close (13.08 and 19 mmHg, respectively),[31] thereby demonstrating a tremendous overlap in frequency distributions. Glaucomatous visual field defects do not always develop in the presence of IOPs that persist between 21 and 30 mmHg, but the majority of glaucoma patients with glaucomatous visual field defects have been found to have pressures in the 21–30 mmHg range.[30]

Other ocular factors

In earlier studies, a large optic disc[86,87] or large cup-to-disc ratio[88] was believed to increase the risk for glaucomatous damage. However, a more recent study did not find an association when testing the correlation of optic disc size and susceptibility for glaucomatous nerve fibre loss.[89] Thus a large cup-to-disc ratio may be indicative of the disease in its early stages rather than a risk factor for it.[10]

Myopia appears to be a risk factor for POAG. In Japan, myopic eyes were found to have higher IOPs than hypermetropic eyes.[31] In Italy, people with myopic eyes had a more than five-fold risk of POAG as compared to those without myopia (OR = 5.56, 95% CI = 1.85–16.67).[66] Two other studies[90,91] found a statistically significant association only between severe, as opposed to mild, myopia and POAG.

Primary Angle-closure Glaucoma

Incidence

Data regarding the incidence of PACG are not readily available. However, a recent population-based incidence study[92] examined residents aged 40 and over in an almost entirely white community in the US and estimated the annual age- and sex-adjusted incidence of PACG to be 8.3 per 100,000 population. Since many have cited race as playing an important role in PACG (see section below), one would expect the incidence of disease to vary according to the racial makeup of a population.

Prevalence

Prevalence rates of PACG from population studies range from 0.01 to 6.1% (Table 3).[16,17,25,31,32,93–96] Examination of these rates emphasizes the excess risk associated with ethnicity; in fact, the prevalence of PACG among the Inuit has been reported to be at least 20 times greater than among Caucasians.[97] Cross-sectional studies of Asians[93] revealed high frequencies of PACG, with the lowest frequency among the Japanese.[31] The considerably lower rate observed in Japan may be explained by the diagnostic criteria used. The presence of PACG required an IOP greater than 21 mmHg plus a closed or occludable angle. Subjects who reported intermittent glaucomatous symptoms or previous acute attacks that would damage the optic nerve head were not included. One author suggested that this might explain the extraordinarily high frequency of low tension glaucoma found among the Japanese.[97] Quigley's[13] review of clinic and survey data found PACG to be rare among people of African descent.

Risk Factors

In the review by Congdon et al.,[97] age, sex and race were identified as important risk factors for PACG.

TABLE 3

Prevalence of primary angle-closure glaucoma among persons 40 years and older, from cross-sectional studies

Study (Year)	Age group	*N*	No of cases	Crude prevalence (%)
Beaver Dam, US[25] (1988–1990)	43–84	4926	2	0.04
Roscommon, Ireland[16] (1990)	50+	2186	2	0.01
Mamre, South Africa[32] (1992)	40+	987	23	2.30
Japan[31] (1988–1989)	40+	8126	28	0.34
Doumen, China[93] (1990)	45+	932	6	0.64
Mongolia[17] (1995)	40+	942	14	1.40
Alaskan Inuit[94] (1985)	40+	377	10	2.65
Copenhagen, Inuit women[95] (1978)	40+	63	2	3.20
Greenland Inuit[96] (1969)	40+	344	21	6.10

Age

Like POAG, PACG rarely occurs before age 50 and prevalence increases with age (Table 4).[17,31,32,93,94,96,98] The frequency of narrow angles and shallow anterior chambers increases with age among Mongolians,[17] Japanese,[31] Chinese,[93] the Alaskan Inuit[94,98] and Vietnamese-Americans.[99] A possible explanation for these changes is the thickening of the crystalline lens that eventually pushes forward over time, causing a narrowing of the anterior chamber angle.[97,100]

Race

In comparisons of POAG with PACG, racial variations emerge (Table 5).[13] PACG is more prevalent among the Inuit[13,97,98] and Asians,[13,97,101] and less prevalent among people of European and African descent.[13,101] Salmon and Martell[101] found the difference between the frequency of PACG among blacks (13%) and whites (17%) versus those with strong genetic links to southeast Asia (47%) to be statistically significant ($p<0.001$).

Reasons for these differences between races have been attributed to the configuration of the eye.[97] In general, both the Inuit[7,102,103] and Asians[7] have shallower anterior chamber depths than Caucasians. Eyes at risk for PACG are usually smaller in length and have shallower anterior chamber depths. One review of several studies pointed out that such characteristics were observed consistently in eyes with PACG among Caucasians, Inuit and Asians, and that, in general, Inuit had narrower

TABLE 4

Prevalence of primary angle-closure glaucoma by age and sex

Study (Year)	Age	Prevalence (%)	
		Men	Women
Mongolia (1995)[17]	40–49	0.0	0.8
	50–59	0.8	1.3
	60–69	2.5	4.9
	70+	7.5	0.0
	40+	1.5	1.5
Japan (1988–1989)[31]	30–49	0.0	0.0
	50–69	0.17	0.49
	70+	0.70	0.85
	30+	0.21[a]	0.38[a]
Mamre, South Africa (1992)[32]	40–49	0.0	1.5
	50–59	1.0	0.7
	60–69	2.3	5.2
	70+	2.3	11.9
	40+	1.0	3.2
Alaskan Inuit (1986–1987)[98]	<50	0.0	0.0
	50–59	3.1	3.6
	60–69	2.6	11.8
	70+	3.7	11.8
	40+	2.1	5.5
Alaskan Inuit (1985)[94]	50+	0.24	0.94
Greenland Inuit (1969)[96]	40+	1.9	9.9
Doumen, China (1990)[93]	45+	0.3	0.3

[a]Based on a sample of 8924 people

TABLE 5

Estimated ratio of primary open-angle glaucoma to primary angle-closure glaucoma by race by the year 2000[13]

Racial origin	Ratio[a]
China	1:3
India	1:1
South Asia	1:1
Europe	11:1
Africa	152:1
Latin America	2:1
Near East	2:1

[a] Ratios calculated from Reference 13

angles than Caucasians.[97] Genetic selection for smaller eyes with crowded anterior chamber depths forces the cornea closer to the iris and ciliary body.

Alsbirk[104] postulated that geographic location comes into play here since winter months with longer periods of darkness can act as a provocative test for PACG. There is much evidence to support this; Inuit who moved from Greenland to Denmark were found to have deeper anterior chambers and a lower prevalence of PACG than the cohort who remained behind.[95] Also, a retrospective analysis of hospital data in Finland demonstrated that the incidence of acute PACG is associated with the number of hours of sunshine.[105] Both earlier and more recent population studies confirmed this finding.[31,94]

In their review of PACG, Congdon et al.[97] found data indicating that the Chinese have shallow anterior chamber depths, but less so than the Inuit. They noted that the Chinese were susceptible to creeping angle-closure, a chronic form of PACG. Since there is a high proportion of Chinese with oculometric risk factors for PACG, they suggested the existence of a population tendency to develop creeping angle-closure, which may explain the high prevalence among this race. In the Mongolian study, 12 of the 14 PACG cases had chronic, asymptomatic PACG.[17]

Sex

Women have been reported to be at higher risk for PACG.[97] Table 4 shows that Japanese,[31] South African[32] and Inuit[96,98] women have higher prevalences of PACG than the men, while no sex difference was observed among Mongolians[17] and Chinese.[93] Numbers of cases were too low to draw conclusions in the studies of Europeans. The reasons for variations by sex are not entirely clear. It has been suggested that Caucasian, Inuit and Asian women have shallower anterior chamber depths and/or narrower angles than the men, but it is not certain that these factors explain the differences completely.[104,106–108]

Screening and Diagnosis

A thorough examination for glaucoma may follow a protocol such as that outlined in Table 6.[9] A positive evaluation of one or any combination of the first four components listed is an indication that further testing is required. Major factors in the definitive diagnosis of POAG include cupping of the optic nerve head, glaucomatous visual field defects and often, but not always, a raised level of IOP.[12] Shallowing of the anterior chamber is the key diagnostic element for PACG.[12] Although glaucoma is readily detectable in its advanced stages, the presence or absence and severity of conditions vary in the early stages of the disease and for each person. Such circumstances make diagnosis very difficult and demand frequent assessments.[2,11]

Various diagnostic techniques are used to determine the presence or absence of glaucoma, including tonometry, perimetry, gonioscopy and ophthalmoscopy.

TABLE 6

Components of an examination for the presence of glaucoma

Required	Personal and family history — ocular and systemic
	Personal history — current and past medications
	Tonometry
	Slit-lamp examination
	Gonioscopy
	Threshold visual field test
	Optic nerve head evaluation
	Nerve fibre layer evaluation
Optional	Stereoscopic optic nerve head photography
	Nerve fibre layer photography
	Provocative testing
	Temporal and spatial contrast sensitivity
	Colour vision testing
	Electrodiagnostic testing

Source: Adapted from Reference 9

Tonometry measures the level of pressure in the anterior chamber resulting from the amount of aqueous present at the time of reading. It is a measure of the force necessary to either flatten or indent the cornea.[2] In the past, one tonometric reading would place an individual into one of the following classifications for glaucoma: normal (<21 mmHg), suspicious (21–24 mmHg) or abnormal (>24 mmHg).[109] However, the existence of POAG associated with a raised IOP at the time of testing is not as common as was once believed. Only half of those with glaucoma will have elevated pressures on random testing,[10] and 25% of those with persistent low tension glaucoma will never have an IOP above 21 mmHg.[14] Also, fluctuations in tonometric readings occur throughout the day since IOP is known to have a diurnal variation.[2] The sensitivity and specificity of tonometry are poor when tonometry is used as a sole indicator of the disease;[84] in one study,[110] a 6% variation in three measurements per person was demonstrated, and in a population screening program, 50% of those with glaucoma were missed with tonometry.[26]

Glaucomatous visual field defects begin in the area of peripheral vision and, if untreated, progress to a point of tunnel vision prior to complete blindness.[11] Automated or computerized perimetry can screen the entire field of vision,[9] thus enabling the determination of peripheral vision loss. From this, the extent of POAG can be evaluated.[1] Although very sensitive and specific, automated perimetry is an expensive screening tool that detects glaucoma at a stage when it is irreversible.[12]

Gonioscopy is a biomicroscopic examination of the anterior chamber angle of the eye, in which a mirrored lens is placed on the cornea, giving the examiner a direct view of the angle between the iris and the surface of the trabecular meshwork.[7] An angle of 20° to 45° is considered to be wide; an angle of less than 20°, narrow. With a narrower angle, the iris sits closer to the meshwork and angle-closure is more likely.[7] Gonioscopy is a simple test that allows for identification of eyes predisposed to angle-closure. As well, this test can detect precipitates or anatomical changes that may change the trabecular meshwork.[7,9]

Ophthalmoscopy is the examination of the optic nerve head using an ophthalmoscope. The colour and appearance of the optic disc indicate whether or not there is damage from glaucoma.[7] This test would show cupping of the optic disc if POAG were present.[1] Unfortunately, the sensitivity and specificity of this screening tool are poor.[111]

Screening tests should be able to identify individuals during the early, asymptomatic period of the disease so that treatment can be started. In this way, screening programs could achieve the goal of significantly reducing visual disability.[10] In the case of glaucoma, reliable surveillance parameters are needed that can identify eyes at greatest risk of visual field loss and then monitor them over time for progressive change.[112]

Recent population studies[16,17,29–31] reveal that only half of the people who really have glaucoma have been diagnosed, and this proportion is likely smaller in developing countries.[13] Tonometry and cup-to-disc ratios require less skill and time than does visual field testing; however, they are not able to achieve adequate balances of sensitivity and specificity either alone or in combination, even with the inclusion of known risk factors.[26,112] The reason for this is that many cases have normal IOPs and cup-to-disc ratios in the presence of glaucomatous visual field defects.[14] Even if visual field testing was the sole screening method, the prevalence of definite glaucoma could be either overestimated or underestimated since many people fail the test.

The inaccuracy of the structural and functional parameters used in current screening protocols is disturbing because we know that retinal nerve fibre layer defects can occur up to six years before the first detectable sign of a glaucomatous visual field defect.[113,114] One study identified more than 90% of glaucoma suspects as having nerve fibre layer defects before the visual field defects had developed.[115] Some investigators suggest that photographic examinations of the retinal nerve fibre layer should be part of the glaucoma screening process.[116,117] Balances of sensitivity and specificity vary, with sensitivity ranging from 65 to 93% and specificity ranging from 84 to 89%.[113,116]

Even if a screening technique were perfected for mass screenings, the clinician would then have to decide whether or not to treat the patient since therapeutic complications do arise.[118,119] Some North American organizations recommend complete eye examinations, including tonometry, in persons aged 35–40.[5] In 1989,

the US Preventive Services Task Force recommended that those aged 65 and over be tested for glaucoma.[5] In contrast, the Canadian Task Force on the Periodic Health Examination recommends periodic ocular examinations only for people who are black, have a family history of glaucoma, or have severe myopia or diabetes.[5]

Treatment

Current treatment for POAG consists of drugs, laser trabeculectomy or surgery. The purpose of each modality is to lower IOP. Lowering IOP has not always arrested progression of the disease,[14] but recent evidence suggests that pressure levels were not lowered sufficiently to stop disease progression.[120] Treatment for PACG consists of drugs, filtration surgery and peripheral iridotomy.[121] An extensive review of glaucoma treatment is beyond the scope of this series, thus the reader is referred to an existing in-depth review.[20]

Conclusion

Age is a major risk factor for both primary glaucomas and both are more prevalent after age 50. Other variables that increase with age are intraocular pressure, narrow angles and shallow anterior chambers. People of African origin experience POAG more frequently and at a younger age than other racial groups, while PACG occurs more commonly among the Inuit and Asians. The positive association with family history, particularly in a sibling and a mother, remains an important risk factor both for glaucoma and ocular hypertension. Diabetes as a pre-existing condition also increases the risk of glaucoma. Knowledge of such risk factors could be used in screening for glaucoma in general practice settings.

These ocular disorders will become a serious public health concern because people at risk, those aged 40 and older, are a growing segment of the population. Increased awareness of the risk factors in primary care settings and optometry clinics coupled with thorough ophthalmologic examinations should substantially help in the screening process. More important, though, is the need for a quick and valid method of screening for glaucoma in its early stages. In this way, national screening programs could identify and effectively treat large numbers of people and substantially reduce the burden of glaucoma. A greater understanding of the pathophysiology of the disease will help to achieve this end.

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Critical Appraisal of the Health Research Literature: Prevalence or Incidence of a Health Problem

Patricia L Loney, Larry W Chambers, Kathryn J Bennett, Jacqueline G Roberts and Paul W Stratford

Abstract

This article identifies and discusses criteria that can be used by health professionals to critically appraise research articles that estimate the prevalence or incidence of a disease or health problem. These guidelines will help determine the validity and usefulness of such community assessment studies. The criteria relate to the validity of the study methods (design, sampling frame, sample size, outcome measures, measurement and response rate), interpretation of the results and applicability of the findings. The research question "What is the prevalence of dementia in Canada?" is used as an example for this paper.

***Key words**: critical appraisal; dementia; prevalence*

Introduction

The published health research literature often contains valuable information that provides the necessary scientific evidence to help direct health policy decisions. Critical appraisal of this literature is important to identify and separate useful from useless information. We found no formalized guidelines for the critical appraisal of research articles that estimate the prevalence and/or incidence of a health problem. The purpose of this paper is to identify and discuss criteria that can be used to assess the methodological strengths, results and relevance of articles on prevalence or incidence of a health problem. We use a health research question regarding the prevalence of dementia in Canada to help clarify these guidelines with examples.

Prevalence or Incidence

Prevalence refers to the proportion of a defined population at risk that has a defined health problem at a particular point in time (point prevalence) or during a period of time (period prevalence).[1] It is usually measured by surveying a particular population containing people with and without the condition of interest,[2] and prevalence rates are usually reported as percentages. For chronic disease conditions that do not resolve, individuals cannot become classified as prevalent cases again. This differs from individuals with acute conditions that resolve completely and can occur again (e.g. low back pain).

By comparison, *incidence* refers to the frequency or number of new occurrences of a health problem (clinical condition) in a population of susceptible individuals who were initially free of that condition before the time period being examined.[1,3] In summary, incident cases are new cases while prevalent cases are the total number of existing cases, old and new, for the time period studied.

Dementia

Dementing disorders are common among the elderly, especially the very elderly.[4] The onset is gradual, and determining the point that distinguishes disease from normality can be difficult.[5] Dementia is characterized by a profound influence on cognitive functioning in addition to the behaviour and emotional state of the person affected.[6] Screening instruments such as the Mini-Mental State Examination[7] (MMSE) are used for screening cognitive decline. Diagnostic criteria such as the DSM III-R[8] assist in diagnosing dementia. The terms used in the DSM III-R criteria to indicate the severity of dementia are mild, moderate and severe.

Author References

Patricia L Loney, Larry W Chambers, Kathryn J Bennett, Jacqueline G Roberts and Paul W Stratford, Department of Clinical Epidemiology and Biostatistics, Faculty of Health Sciences, McMaster University, Hamilton, Ontario

Correspondence: Jacqueline Roberts, System-Linked Research Unit, McMaster University, HSC 3N28, 1200 Main Street West, Hamilton, Ontario L8N 3Z5

Materials and Methods

Literature Search

The search strategy used for this paper included a computerized search, personal files and references from articles. We searched the MEDLINE CD-ROM from 1992 to 1996, using the MeSH headings "dementia," "Alzheimer's disease" and "prevalence." The search was limited to studies printed in English and to study subjects aged 65 and over. Nine articles were identified, originating from different countries that reported prevalence rates of dementia for people in the 65+ age group.[4,6,9,10–15] According to these articles, prevalence rates for dementia varied from 2% in Taiwan to 4% in the United States, 5% from two studies in Spain, 6% in Japan, 8% in Canada and Italy, and 9% in Belgium and Holland.

Critical Appraisal Background

Several published review articles[16–19] have identified criteria indicating the validity of research articles determining prevalence. Jorm et al.(1987)[16] identified that the design of the study, characteristics of the sample and methods of assessment and diagnosis were important features. Rockwood and Stadnyk (1994)[18] outlined specific criteria that included the study's purpose, design, sampling frame or method of subject recruitment, sample size, population demographics, location and reporting of the prevalence related to subgroups. In the review by Forbes and Barham (1991),[19] adequate response rates were emphasized along with the concern of trying to identify mild cases of dementia. Corrada et al. (1995)[17] reported that they coded studies according to features related to whether studies included mild cases, institutionalized persons and appropriate diagnostic and screening measures.

We incorporated many of the above criteria in our development of critical appraisal criteria for prevalence or incidence studies.

Critical Appraisal Guidelines and Scoring

We developed three broad organizing questions to structure the critique of articles determining the prevalence or incidence of a health problem or clinical issue, as illustrated in Table 1.

For our specific critique example, two authors appraised the selected articles on the prevalence of dementia, using consensus, based on the guidelines outlined in Table 1. They used a methodological scoring system[20] previously used to rate the quality of studies on the prevalence of back pain (Table 2). To determine the relative weighting of each item for the scoring system, three authors were asked to recommend weights for each item and all agreed that each item should be weighted equally. Thus each item was assigned a score of 1 point, making 8 the maximum score possible.

TABLE 1

Guidelines for critically appraising studies of prevalence or incidence of a health problem

A. ARE THE STUDY METHODS VALID?

1. *Are the study design and sampling method appropriate for the research question?*
2. *Is the sampling frame appropriate?*
3. *Is the sample size adequate?*
4. *Are objective, suitable and standard criteria used for measurement of the health outcome?*
5. *Is the health outcome measured in an unbiased fashion?*
6. *Is the response rate adequate? Are the refusers described?*

B. WHAT IS THE INTERPRETATION OF THE RESULTS?

7. *Are the estimates of prevalence or incidence given with confidence intervals and in detail by subgroup, if appropriate?*

C. WHAT IS THE APPLICABILITY OF THE RESULTS?

8. *Are the study subjects and the setting described in detail and similar to those of interest to you?*

TABLE 2

Methodological scoring system used to rate studies reviewed[20]

Item		Score
1.	Random sample or whole population	1 point
2.	Unbiased sampling frame (i.e. census data)	1 point
3.	Adequate sample size (>300 subjects)	1 point
4.	Measures were the standard	1 point
5.	Outcomes measured by unbiased assessors	1 point
6.	Adequate response rate (70%), refusers described	1 point
7.	Confidence intervals, subgroup analysis	1 point
8.	Study subjects described	1 point
	Maximum score	**8 points**

Critical Appraisal of Studies

A. ARE THE STUDY METHODS VALID?

1. Study Design and Sampling Method: Are the study design and sampling method appropriate for the research question?

A survey (observational study) is the appropriate study design to determine the prevalence of a particular health problem. If the whole population of interest is not surveyed, then the best sampling technique is random (probability) sampling of persons from a defined subset of the population. Stratification (sampling purposely from subgroups) may be required to appropriately represent subgroups such as the very old. Stratified random sampling, with eligibility criteria, will ensure that the sample is representative of the population to whom the researchers wish to generalize the results.

For larger surveys, cluster sampling is sometimes used. In cluster sampling, groups of individuals (e.g. families or people living in defined geographical areas) are selected as the survey units.[3] If the population is small, some studies survey the whole population and do not generalize the results to other populations.

A study to determine the incidence of a disease must have a prospective or longitudinal design, and should include persons known not to have the disease, who are then observed over a suitable time period.[1,3]

As an example, one of the studies reviewed in our critical appraisal of studies on the prevalence of dementia in Canada was the Canadian Study of Health and Aging (CSHA).[15] This was a survey that covered five regions across Canada through a random sample of 10,263 persons in community and institutional settings to determine the prevalence of dementia and Alzheimer's disease. The CSHA used random sampling, stratified for age, sex, region and place of residence (community or institution).

2. Sampling Frame: Is the sampling frame appropriate?

The type of sampling frame (list for study recruitment) from which subjects are selected is important. Census data provide one of the few data sets from which one can draw a sample that is thought to have minimal bias since certain groups of persons are thought not to be excluded as they might be in an electoral list or telephone list. For example, electoral lists may underrepresent the elderly or people who are cognitively impaired. In relation to our critical appraisal of dementia prevalence studies, a sample of "convenience" could be very biased in that persons with dementia were hard to reach, thus reducing the prevalence of dementia in the sample. Studies of whole, narrowly defined communities are usually done as door-to-door surveys, but this limits the generalizability of the findings outside that community.

In the Canadian Study of Health and Aging,[15] the following databases were used for sample selection: provincial health insurance plans, enumeration composite records, election records and municipal records. The study included both institutionalized persons and community dwellers. In the one province (Ontario) where election records were used, the sample may have been biased if the extreme elderly were missed.

Bachman et al. (l992)[10] used the Framingham cohort in the United States, which limits the generalizability of these results to a particular group of subjects. Some electoral or physician utilization lists might not represent all elderly persons (i.e. both those in the community and those in institutions, and healthy and unhealthy seniors), and thus might underrepresent persons with dementia.

3. Sample Size: Is the sample size adequate?

A large sample size produces narrow confidence limits, which is doubly important if the prevalence or incidence of a given condition is low. Small sample sizes produce large confidence intervals, making the findings less precise. It is critical to be as confident as possible that any changes in health care policy are based on results that did not occur by chance due to probability sampling inadequacy. In fact, the sample size required to estimate a proportion (prevalence of a disease) with a specified degree of precision (i.e. 95% confidence) can be calculated.[21]

Using a conservative sample size estimate of proportions for our review of dementia prevalence studies (assumptions based on CSHA study:[15] prevalence = 8%, error rate <3%, 95% confidence level), the calculated sample size needed would be 314.[21] In their study of dementia prevalence, Rockwood and Stadnyk (1994)[18] indicated that the sample should be at least 300 subjects. Thus, a sample size of 300 was considered adequate for the purposes of our review. If prevalence rates were needed for subgroups, then the suggested sample size would be required for each subgroup.

The sample sizes used in the dementia prevalence studies we critiqued varied from 500[13] to 10,263.[15] The largest sample, from the CSHA, produced smaller error rates and smaller confidence intervals, which is important when making a health care decision or policy.

4. Appropriate Measurement: Are objective, suitable and standard criteria used for measurement of the health outcome?

Often crude outcome measures are used in population health research due to the expense of complicated diagnostic tests. However, these measures may not be capable of including or excluding appropriate levels or stages of the health problem. It is important that published studies describe the measurements used well enough that the different outcome measures can be compared. If a worldwide standard measure of a particular health outcome exists, any studies not using it should indicate how their measure is related to the more common accepted measure.

The outcome measure must be reliable (reproducible) and valid with high sensitivity and specificity. Since health problems can be defined in many ways, the measurement of the problem must be the best possible one used by health care providers. If a disease is rare, there are often two phases to a prevalence study: subjects are first screened quickly for the condition using an inexpensive, broad screening test with good sensitivity and specificity, and then more complicated and detailed clinical assessments are made in the second phase. The screening test should not miss true positives—people who truly have the disease—and

it should also have a low false negative rate, meaning it does not incorrectly label subjects with the disease as being disease-free.

For example, dementia is sometimes classified in research studies according to different systems from the United States (DSM), continental Europe (International Classification of Diseases) and the United Kingdom (CAMDEX: Cambridge Mental Disorders of the Ederly Examination).[22] Research has indicated that these commonly used criteria can differ by a factor of 10 in the number of subjects classified as having dementia.[22] In the CSHA,[15] a variety of measures were used by independent assessors who were unaware of the initial screening test results. The community screening measure was the Modified Mini-Mental State Examination (3MS),[7] which was given by trained interviewers in the subject's home. Subjects who screened positive (score <78) and a randomly selected group of subjects who screened negative were given clinical examinations by a nurse, a psychometrician (blind to 3MS testing), a neuropsychologist and a physician. These health professionals were trained and given guidance about how to assess for dementia. In addition, biological tests were carried out. Other assessments included the DSM III-R criteria[8] and CAMDEX.[23] In the American Framingham study,[10] presence of dementia was determined through the MMSE,[24] the CES-D[25] (Center for Epidemiologic Studies Depression Scale) and general examinations by an independent neurologist.

Many health problems are not easily diagnosed or defined, and some, such as dementia, include stages where mild cases are not always easily distinguished.

5. Unbiased Measurement: Is the health outcome measured in an unbiased fashion?

Considerable judgment by assessors or interviewers is required to determine the presence of some health outcomes under scrutiny; thus, it is best that trained assessors are independent and not aware (i.e. blinded) of the subjects' clinical status or, sometimes, even the purpose of the study. It is important that the subjects under assessment include those thought to be negatives as well as positives.

If more than one rater is used, interobserver and/or intraobserver reliability of clinical assessments must be high and should be noted in the articles published. The interviewers or assessors must all be using the same criteria, including specifics related to each health problem, such as its duration. This is especially pertinent when diagnosing an illness such as Alzheimer's disease, since investigators must evaluate clinical signs and symptoms in the subjects in addition to caregivers' views of these. Sometimes, as for Alzheimer's disease, multiple measurements or assessments are conducted to rule out other health conditions. Thus the numerators (health problems) of the rates must all be defined or diagnosed in the same way.

6. Response Rate: Is the response rate adequate? Are the refusers described?

The greater the number of selected subjects who are not available for measurement, the less valid the estimate. A response rate in population surveys of two thirds to three quarters has been suggested to be generalizable to the population samples.[26] Therefore, we chose a response rate of 70% as acceptable in our review. In the case of dementia, a significant proportion of those persons not responding to a survey might be suffering from dementia, which could lead to an underestimate of its prevalence.[19]

Since a large number of dropouts, refusals or "not founds" among the subjects selected may jeopardize a study's validity, the authors should describe the reasons for non-response and compare persons in the study with those not in the study as to their sociodemographic characteristics. If the reasons for non-response seem unrelated to the health outcome measured and the characteristics of those individuals not in the sample are comparable to those in the study, researchers may be able to justify a more modest response rate.

Response rates may be improved if the assessment or measurement is easily accessible, conveniently timed for the subjects, acceptable in length and suitable in content. Home visits may be more acceptable for many elderly persons.

In our review, prevalence rates of dementia differed as did study response rates. The CSHA[15] accounted for all subjects, giving reasons for non-response. The compliance rate for the initial screening (phase 1) was 72%, and 73% of these respondents were compliant for clinical examination during the prevalence study. The CSHA authors considered these rates slightly low and thought that dementia prevalence might be underrepresented in the sample since 27% refused the clinical exam and their reasons for refusal might have included the presence of dementia.

To determine incidence ideally, all study subjects should be followed and measured to prevent bias. Usually patients are available for follow-up and if randomly selected subjects are not found or studied, one is never sure if there is a consistent bias known to influence incidence. If persons die during the period of the study, the cause of death must be ascertained. It is necessary to follow subjects over a clinically sensible period of time, depending on the illness under study and the age of the population. For dementia, if the follow-up period is too long, cases may be missed due to death, especially in the older subgroups.

B. WHAT IS THE INTERPRETATION OF THE RESULTS?

7. Results: Are the estimates of prevalence or incidence given with confidence intervals and in detail by subgroup, if appropriate?

The quantitative results from studies of prevalence or incidence are proportions or rates over a fixed period of time. The prevalence rates found in studies reviewed provide only estimates of the true prevalence of a problem in the larger population. Confidence intervals then indicate the level of confidence one can have in the estimates and their range. Since some subgroups are very small, usually 95% confidence intervals are given.

The CSHA authors[15] provided confidence intervals and described prevalence rates in detail by age group, sex, setting (community or institution) and region of Canada. Their estimates of the prevalence of dementia ranged from 2.4% among persons aged 65–74 years, to 34.5% among those aged 85 and over.

C. WHAT IS THE APPLICABILITY OF THE RESULTS?

8. Study Subjects: Are the study subjects and the setting described in detail and similar to those of interest to you?

Certain diseases are known to vary in prevalence or incidence across different geographic regions and population sectors. For example, persons over 85 years of age and those residing in institutions are expected to have higher prevalence rates of dementia. For some health problems, rates for women may differ from those for men.

Sociodemographic variables, such as educational status, may vary between countries. Therefore, the study sample needs to be described in enough detail that other researchers can determine if it is comparable to the population of interest to them.

In the CSHA article,[15] study subjects are described in detail by age, sex and region of residence in Canada. Institutionalized subjects are also included in the sample.

If the study being appraised estimates the prevalence of a sign or symptom in an experimental group, such as a control group in a randomized controlled trial, the sociodemographic characteristics of the subjects must be reported in order to understand the applicability of the results. Similarly, providing a comparison of study participants with those who refused or were ineligible can help others determine for whom the study group is representative.

Conclusion

Table 3 summarizes the findings from our critical appraisal of studies on the prevalence of dementia according to the guidelines we developed. Prevalence rates from these nine studies varied from 2% to 9%, and the scores we assigned varied from 3 to 8, the maximum possible.

Some of the studies seemed inappropriate for determining the prevalence of dementia in Canada due to the lack of relevance of the subjects studied, while others had methodological weaknesses. For example, if the assessors did not have negatively screened subjects included in their sample, the results might be biased. In addition, some studies had low response rates, raters were not always blinded and the sampling frames were not always the best.

The study by the CHSA Working Group estimated the prevalence of dementia in Canada to be at least 8%. The sample was randomly selected, subjects in institutions were included and outcome measures were appropriate. The results included subgroup analysis, the sample size was large and the setting and subjects were applicable to our community situation. We found the weaknesses of the study to be a slightly low response rate and use of electoral lists in one province, suggesting an underreporting of cases of dementia. Our final rating of this study was a favourable score of 7.

Discussion

We developed and applied guidelines for the critical appraisal of published articles estimating the prevalence of dementia. These guidelines incorporated and organized many existing criteria indicating the validity of research articles on disease prevalence. We investigated the prevalence of dementia in Canada to help clarify the criteria.

The guidelines here can be used in the critical appraisal of published research concerning most health conditions to assess the "burden of illness,"[27] prevalence or incidence. Once the true burden is known, based on methodologically sound research, health policy makers can use this information to aid in organizing and prioritizing community health care.

TABLE 3

Critical appraisal of studies of the prevalence of dementia

Study and setting	Sample size (*n*)	Sample design	Sampling frame	Measures	Unbiased assessors	Response rate and refusers	Prevalence rates	Score [a] and limitations
Bachman (1992)[10] USA — Boston	2180	Framingham >60 years	Group practice	3-phase design: 1. MMSE screen, neuroassessment Cummings & Benson criteria 2. DSM III-R 3. Neuropsychology tests	Neurologist and neuropsychologist Review panel Negative screens not assessed	42% of original cohort 81% of positive screens	4.4% >65 years No CI given Subgroups	**Score 3** Closed group Poor response rate Refusers not described No CI Negative screens not assessed
Coria (1993)[11] Spain — rural community	500	All individuals in rural community ≥40 years Door to door	Census	2-phase design: 1. Hodgkin's screen 2. CEMED and DSM III-R	University students and neurologist Negative screens not examined	99.4% Refusers described	5.2% >64 years CI = 2.6–9.3 Subgroups	**Score 7** Negative screens not examined
Lobo (1995)[13] Spain — Zaragoza	1080	Random sample ≥65 years Sampling with replacement	Municipal census list Stratified	2-phase design: 1. GMS,[b] MMSE screen with neurologic exam 2. DSM III-R	Medical students and research psychiatrists Blinded Negative screens included	95% phase 1 88% phase 2 Refusers described	5.5% ≥65 years CI = 2.9–8.0 Subgroups	**Score 7** Question sampling with replacement
Komashashi (1994)[9] Japan — Ohira town	2688	All individuals in rural town ≥65 years	Door to door No residents of institutions	2-phase design: 1. troublesome behaviour and depression Q's screen 2. clinical exam and DSM III-R	1. Welfare commissioners (collected questionaires) 2. Psychiatrist and nurse Negative screens not included	78.7–86.4% Refusers not described	6.1% ≥65 years No CI given	**Score 4** Unusual phase I screen No CI given Refusers not described Negative screens not assessed
Ott (1995)[4] Holland — Rotterdam	7528	Participants ≥55 years from Rotterdam	All residents Rotterdam substudy	3-phase design: 1. MMSE, GMS screen with CAMDEX 2. neurologic exam 3. DSM III-R	Research assistants, neurologist and neuropsychologist Negative screens not examined	73% Refusers not described	9.4% ≥65 years No CI given	**Score 5** Refusers not described No CI Negative screens not assessed
CSHA (1994)[15] Canada — community and institution	10263	Random sample of individuals ≥65 years	Medicare & enumeration, residents of institutions	2-phase design: 1. 3MS screen (also MMSE criteria) with clinical evaluation 2. DSM III-R	Interviewers and clinical team (nurse, psychometrician, neuropsychologist, physician) Negative screens included	73.5% Refusers described	8.0% ≥65 years CI given	**Score 7** Sampling frame somewhat limited
Prencipe (1996)[14] Italy — 3 rural villages	968	All individuals ≥65 years	All individuals ≥65 years from door to door	2-phase design: 1. MMSE screen with clinical evaluation 2. DSM III-R	Trained lay interviewers and doctors Observer reliability: K=0.83 for screen Negative screens not assessed	84% Refusers described	8.0% ≥65 years CI= 6.3–9.8	**Score 7** Negatives from screen not examined
Roelands (1994)[6] Belgium — rural Heist-op-den-Berg	1736	Random sample, stratified by age, sex ≥65 years	Population register Institutions included	2-phase design: 1. MMSE screen with CAMDEX 2. DSM III-R	Psychology students, psychiatrist, psychologist, and neuropsychologist Negative screens included	82% Refusers described	9% ≥65 years CI given for age groups	**Score 8**
Liu (1995)[12] Taiwan — rural and urban	5297	Cluster sampling of individuals ≥40 years	Door to door Institutions in Taiwan not used for elderly	2-phase design: 1. MMSE-T1 with neuroassessment 2. DSM III-R 1.5 yrs later	Trained nurses, neurologist, senior neurologist and neuropsychologist No negatives in phase 2	83% phase I 95% phase II Refusers not described	2% ≥65 years CI=1.26–2.68	**Score 6** Negative screens not assessed Refusers not described

[a] Score = Methodological strength of study (maximum 8) [b] GMS = Geriatric Mental State Schedule

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Surveillance of Drug Overdose Deaths Using Medical Examiner Data

Christiane Poulin, Jonathan Stein and John Butt

Abstract

This paper describes the epidemiology of drug overdose deaths investigated by the medical examiner in one of the cities participating in the Canadian Community Epidemiology Network on Drug Use and assesses the quality of the information obtained from medical examiner charts with respect to drug overdose deaths, for surveillance purposes. Information was abstracted from medical examiner charts of all deaths involving drugs from 1993 to 1995 in Halifax, Nova Scotia. During these three years, 636 deaths from all causes were investigated by the medical examiner. Of the 42 overdose deaths, 47.6% were suicides. Ethanol was detected in 47.8% of overdose deaths, and 61.9% of all overdose deaths involved psychotropic medications. Two deaths were attributed to an illicit drug (cocaine). An independent review performed by a toxicologist and a medical examiner revealed poor overall agreement concerning overdose as a cause of death (Kappa coefficient: 0.27). In conclusion, the average crude mortality rate due to drug overdose in Halifax from 1993 to 1995 was 4.1 deaths per 100,000 population. Potential threats to the quality of data were the lack of standardization concerning toxicological testing and the definition of drug overdose.

Key words: *Canada; drug overdose death; epidemiology; surveillance*

Introduction

Death due to overdose is one of the most dire consequences of drug abuse. Overdose deaths can be intentional or unintentional, and they can result from both licit and illicit drug abuse. Drugs commonly implicated in overdose deaths are alcohol, psychoactive medications, analgesics, illicit drugs such as cocaine and heroin, and multiple drugs taken concomitantly.

In Vancouver, the crude mortality rate due to overdose of an illicit drug increased eightfold among males over four years, from 2 per 100,000 in 1989 to 16 per 100,000 in 1993.[1] This was considered an epidemic, and the evidence suggested that young or naive users were at high risk of overdose because of especially pure heroin.[1] Toronto also experienced a rise in heroin deaths such that, in 1992, the crude mortality rate due to heroin overdose was 1.4 deaths per 100,000.[2] Elsewhere in Canada, little is known about the epidemiology of deaths attributed to licit and illicit drugs.

Drug overdose deaths are medico-legal cases investigated by medical examiners or coroners. Although medical examiner charts are recognized as a key source of information for monitoring such deaths, the accuracy of official statistics on drug mortality remains uncertain.[3–6] Numerous sources of bias have been identified. Selection bias may exist because the deaths of persons not well known to a doctor or with little access to health care are more likely to be investigated by a medical examiner than are deaths of persons known to the medical system.[7] Medical examiners can be pressured by insurance companies to classify a death as a suicide, by the deceased's beneficiary to classify it as accidental, or by family members to report a less stigmatizing cause of death.[5,7,8] In addition, the experience, residence and religion of medical examiners can influence their investigative and reporting decisions.[9]

Establishing death due to overdose is a medico-legal decision that can be based on a wide assortment of

Author References

Christiane Poulin, Associate Professor, Department of Community Health and Epidemiology, Faculty of Medicine, Dalhousie University, 5849 University Avenue, Halifax, Nova Scotia B3H 4H7; E-mail: Christiane.Poulin@dal.ca
Jonathan Stein, University of Toronto, Toronto, Ontario
John Butt, Chief Medical Examiner of Nova Scotia, Halifax, Nova Scotia

evidence: autopsy; toxicological testing; description of circumstances obtained from police, witnesses, persons close to the deceased or who have knowledge of the deceased; suicide notes; medical and psychiatric history including medication and substance abuse; and legal antecedents including those pertaining to alcohol and other drugs. None of these elements of evidence can be said to be necessary or sufficient for a death to be attributed to a drug overdose. Rather, the medical examiner orders, reviews and assesses the collective evidence and arrives at a medico-legal decision based on his/her expert judgement. In particular, a death may be validly attributed to overdose even in the absence of toxicological testing. By contrast, even when toxicological testing reveals the presence of one or more drugs, a death may nonetheless validly be declared as not due to overdose.

The objectives of the present study were to describe the epidemiology of drug overdose deaths in Halifax and to assess the quality of the information obtained from medical examiner charts with respect to drug overdose deaths, for surveillance purposes. Halifax, Nova Scotia, is one of the sentinel cities participating in the Canadian Community Epidemiology Network on Drug Use (CCENDU), a national surveillance system on substance abuse.

Setting

The systems for the investigation of deaths vary across provincial jurisdictions.[12] In Nova Scotia, the 1989 Fatality Injuries Act requires medical examiners to investigate and determine the cause of death in cases of death due to violence, undue means, culpable negligence or undetermined cause, death in jail or prison, or death in a place or under circumstances requiring an inquest by statute. The Chief Medical Examiner is a medical pathologist appointed by the Governor-in-Council. For the three-year period (1993–1995) of the present study, Halifax was served by the Chief Medical Examiner as well as four medical examiners working on a contract basis. In 1995, the Regional Municipality of Halifax (Halifax) had a population of 342,771 persons.[13]

Methods

The present study recognizes two circumstances concerning death and drugs: death due to overdose, and death where drugs are implicated or detected through toxicological testing but where the final medico-legal decision is not death due to overdose.

This study used a case series of all charts from the Office of the Chief Medical Examiner for deaths investigated in Halifax from 1 January 1993 to 31 December 1995. All charts were reviewed manually in order to identify all cases of death with a final medico-legal disposition of death due to overdose and all cases where a toxicology profile had been obtained, whether or not the results were positive. Only cases where the deceased both resided and died in Halifax were included. Residents of Halifax who died elsewhere were excluded because of insufficient documentation.

The complete medical examiner chart regarding death due to overdose includes a medical examiner report, the results of a toxicology profile if one has been ordered and possibly a psychological autopsy in cases of suicide. The medical examiner defines the cause of death, and the report provides details about the manner and circumstances of death and the results of a medico-legal autopsy. In Halifax, an overdose is classified as intentional only if established conclusively through a note written by the deceased. In our study, cases with a final medico-legal disposition of death due to overdose were abstracted as to sex, age at death, cause of death, manner of death and toxicology results.

In Halifax, toxicology profiles are obtained according to the circumstances of the individual case. Criteria for requesting toxicology profiles are not standardized or explicit. In general, specimens are collected from blood, urine and/or vitreous humour. Toxicological analysis is performed at the provincial laboratory except in criminal cases when analysis is performed at the RCMP forensic laboratory. Initially, blood and urine specimens undergo drug screening techniques. A positive screening test is followed by a confirmatory analysis to identify and quantify the drug present. The provincial laboratory reports only those results that exceed a specific concentration (for example, 10 mg/dl for alcohol). The presence of a given drug in toxicological testing does not exclude the presence of one or more other drugs.

Toxicological testing represents objective evidence that may provide a useful confirmatory component in the surveillance of death due to overdose, for example, as a potential means of identifying false positive cases. However, toxicological testing is not necessarily ordered as part of the investigative process of death due to overdose. Furthermore, in cases where multiple drugs are detected or where levels are not flagrantly in the toxic levels, the decision to attribute a death to drug overdose may hinge on a knowledge of drug interactions and metabolism. In such cases, the expert opinion of a toxicologist may become germane.

Therefore, as part of our study, a toxicologist and a medical examiner each were given a list of the age, sex and toxicology results of all deaths with a final medico-legal disposition of drug overdose, and each independently classified the deaths as either due to overdose or as indeterminate/not consistent with overdose. Agreement between the toxicologist and the medical examiner was assessed using the Kappa coefficient.[14]

Deaths where toxicological testing is performed but which are not ultimately considered as due to overdose do not necessarily have the same level of documentation

as do those with a final disposition of death due to overdose. Thus, it may not be possible to retrospectively identify false negative cases of death due to overdose. Nonetheless, one would expect that, as a group, deaths not considered to be due to overdose would have a different overall mix of toxicology profiles than that of the group of deaths due to overdose. Therefore, the two groups of deaths (overdose and not overdose) were compared in two ways. First, differences in the median number of drugs detected on toxicological testing, which was not normally distributed, were compared using the non-parametric Kruskal-Wallis test. Second, the proportions of deaths where specific categories of drugs were found were compared using the chi-squared test.

The chi-squared test or Fisher's exact test was used to compare the numbers of (i) drug overdose deaths, (ii) cases undergoing toxicological testing and (iii) cases of positive toxicology, as proportions of the total number of deaths investigated in each of the three years. The Fisher's exact test was used to compare the number of cases of suicide among deaths due to overdose during the three-year period, according to sex. Differences in median age at death, which was not normally distributed, were tested using the non-parametric Kruskal-Wallis test. EpiInfo Version 6 was used for data management and analysis.[15]

Results

From 1993 to 1995, 636 deaths of persons who resided and died in Halifax were investigated by a medical examiner (Table 1). Forty-two (6.6%) deaths had a final medico-legal disposition of being due to drug overdose. There was no significant difference in the proportions of overdose deaths over the three years (p=0.67). Therefore, the average annual crude rate of mortality due to drug overdose in Halifax was 4.1 per 100,000 population (14 ÷ 342,771 x 100,000) from 1993 to 1995.

During the same time period, toxicological testing was performed in 292 (45.9%) of the deaths investigated by a medical examiner. A significant increase in the proportion of cases undergoing toxicology tests occurred between 1994 and 1995 (p=0.002) [Table 1]. Cases of positive toxicology were found in 189 (64.7%) of the deaths tested over the three years, with significant differences in the annual proportions from year to year (p=0.034).

Of the 42 cases of death due to overdose, 52% were male. The age at death ranged from 22 to 73 years; the median age at death was 45.6 with no statistical difference over the three-year period (p=0.11). Twenty (47.6%) overdose deaths were suicides, nineteen (45.2%) were unclassified or undetermined and three (7.1%) were unintentional. Suicide was recorded as the manner of death in a larger proportion among females than among males (65% vs 32.8%, p<0.03).

Table 2 lists the drugs implicated and/or detected in the 42 overdose deaths. Toxicological tests were performed on 38 of these cases. Testing was not performed in the remaining four cases where the individuals were admitted to hospital in critical condition. Those four deaths were attributed to overdoses of insulin, valproic acid, verapamil and carbamapezine.

Ethanol was the drug most frequently implicated and/or detected (47.6%) in cases of death due to overdose. Illicit drugs (cocaine and cannabis) were detected in five overdose deaths; however, only two of these deaths had a final medico-legal disposition of death due to overdose of an illicit drug (cocaine). Viewed another way, 61.9% of all deaths due to overdose in Halifax from 1993 to 1995 involved psychotropic medications often prescribed in the treatment of mental health disorders (antidepressants, benzodiazepines, antipsychotics, hypnotics and sedatives).

During the study period, 38 of the 292 cases that underwent toxicological testing received a final disposition of death due to overdose and 254 cases did

TABLE 1

Deaths investigated by a medical examiner, Halifax, 1993–1995

	1993		1994		1995		3-year period	
Number of deaths investigated	221		201		214		636	
Number of (%[a]) deaths with toxicology profiles	87	(41.2%)	86	(42.8%)	119	(55.6%)	292	(45.9%)
Number of (%[b]) deaths with positive toxicology	61	(70.1%)	46	(53.5%)	82	(68.9%)	189	(64.7%)
Number of (%[a]) overdose deaths	12	(5.4%)	14	(7.0%)	16	(7.5%)	42	(6.7%)

[a] Percent of deaths investigated

[b] Percent of deaths with toxicology profiles

not. The number of drugs detected among overdose deaths was significantly greater than that detected among non-overdose deaths (overdose: median 2, 25th and 75th percentiles 2 and 3; non-overdose: median 1, 25th and 75th percentiles 0 and 1) ($p<0.01$). As well, with the exception of alcohol and cannabis, the proportions of deaths in which 11 specific categories of drugs were implicated were significantly greater for overdose deaths than for deaths not due to overdose (Table 2). We conclude that, at the group level, the toxicological profile of drug overdose deaths was significantly different from that where death was designated as not due to overdose.

Finally, the determination of death (overdose or indeterminate/not consistent with overdose) from the 38 toxicology results, independently assessed by a toxicologist and a medical examiner, revealed poor overall agreement between the two reviewers (Kappa coefficient of 0.27).

Discussion

Based on medical examiner investigations as reported, the average annual crude rate of mortality due to drug overdose in Halifax was 4.1 per 100,000 population from 1993 to 1995. The rate of mortality due to drug overdose, for all drugs combined, appears to be low in Halifax. The vast majority of drug overdose deaths in Halifax were due to licit substances, primarily alcohol and prescription psychotropic medications.

TABLE 2

Drugs implicated and/or detected in overdose deaths and drugs detected in non-overdose deaths where toxicology testing was performed, Halifax, 1993–1995

	Overdose deaths (*n*=42*)		Other deaths with toxicology (*n*=254)		χ^2 test
Drugs	**Cases**	**(%)**	**Cases**	**(%)**	***p*-value****
Ethanol	20	(47.6)	98	(38.6)	0.27
Other alcohol[a]	3	(7.1)	1	(0.3)	<0.001
Antidepressants[b]	16	(38.1)	5	(2.0)	<0.001
Medications available without prescription[c]	12	(28.6)	28	(11.0)	0.002
Narcotic analgesics[d]	10	(23.8)	11	(4.3)	<0.001
Benzodiazepines	8	(19.0)	21	(8.3)	0.03
Drugs for major psychiatric or neurologic disorders[e]	5	(11.9)	9	(3.5)	0.02
Hypnotics and sedatives[f]	5	(11.9)	4	(1.6)	<0.001
Other prescription medications[g]	4	(9.5)	0	(0)	<0.001
Cocaine	3	(7.1)	3	(1.2)	0.01
Cannabis	2	(4.8)	6	(2.4)	0.37
Miscellaneous[h]	3	(7.1)	17	(6.7)	N/A

* Toxicological testing was performed for 38 overdose deaths. In the 4 cases where it was not done, overdose was substantiated through other evidence.

** Chi-squared test compares overdose and non-overdose deaths for each specific drug category. It was not performed for the category "Miscellaneous."

[a] Methanol, isopropanol

[b] Amitriptyline, doxepin, impramine, nortriptyline, sertraline, fluoxetine

[c] Salicylate, acetaminophen, diphenhydramine

[d] Codeine, meperidine, morphine, methadone

[e] Methotrimeprazine, trifuloperazine, carbamapezine, valproic acid

[f] Chloral hydrate, butalbital, phenobarbital, zopiclone

[g] Orphenadrine, methocarbamol, verapamil, insulin

[h] Overdose deaths: toluene, hydrocarbon, cyanide; non-overdose deaths: atropine, lidocaine, ranitidine, ketamine

Few drug overdose deaths in Halifax involved illicit drugs, and the rate of deaths actually attributed to an illicit drug was 0.2 deaths per 100,000 population from 1993 to 1995. In contrast, Vancouver recorded 22 deaths per 100,000 population involving heroin, cocaine and other illicit drugs in 1995, and Toronto's mortality rate for heroin as the sole lethal drug was 1.45 deaths per 100,000 population.[10,16] The finding of a low mortality rate for illicit drug overdose in Halifax is corroborated by other population-level indicators collected by the CCENDU.[10,11] Halifax has low per capita numbers of cocaine- and heroin-related law enforcement charges and hospital separations, as compared with Vancouver, Toronto and Montreal.

The most fundamental problem with the quality of the data in the present study was the lack of an explicit definition of *drug mortality*. According to Shai (1994), definitions used by various American institutions range from the broad concept of "drug-induced deaths," which includes deaths from both dependent and non-dependent drugs, legal and illegal drug use, as well as poisoning from medically prescribed and other drugs, to a narrowly defined "drug dependence."[5] Shai defined drug mortality as "deaths due to psychoactive drugs, legal or illegal, through natural causes (chronic or acute narcotism) or accidental or purposive overdose."[5]

Another major potential source of bias in the Halifax data was the apparent lack of uniform methods and interpretive criteria in the medical examiner investigations conducted by a total of five examiners over the three-year period. Toxicological testing was requested without explicit guidelines and was performed on less than half of the deaths investigated.

Toxicology analysis is considered an essental adjunct to anatomical diagnosis in medical examiner cases possibly related to drug abuse.[3,5,6,17,18] Generally, a positive history of drug or alcohol abuse, or the presence of items associated with alcohol or drug abuse at the scene, leads to the requestioning of toxicology tests.[5] Although universal toxicological screening could potentially serve to improve case ascertainment, Tormey et al. (1989) stated that such a strategy would be time consuming, costly and inefficient.[18] Furthermore, universal screening could lead to the identification and potential misclassification of cases of therapeutic and subtherapeutic drug levels of questionable toxicological significance (false positives).[18] According to Jammehdiabadi and Tierney (1991), a thorough history and clinical assessment of the patient who overdosed take precedence over analytical screens in determining what drugs are involved in suspected overdose.[19]

In our study, the poor degree of agreement between the toxicologist and the medical examiner, who independently reviewed the toxicology results, exemplifies the difficulty of judging cause of death, especially where multiple drugs are detected or the levels are not flagrantly in the toxic range. However, our finding of a significant difference in toxicology profiles of the two groups of deaths (i.e. those with a final medico-legal disposition of death due to drug overdose and those without) suggests remarkable consistency within each group and a strong difference between the two groups. Our study might have been strengthened by reviewing the medical examiner charts of the latter group in order to identify cases of false negativity. However, even that procedure would have been fraught with ambiguity because of information bias from variability in wording and completeness of records and from the inter-examiner variation in certification judgements.[5,7,9]

In conclusion, numerous studies have emphasized that suicide, drug overdose deaths, lethal poisonings and injury deaths generally are underreported, whatever the surveillance measure.[3,5–7,20–22] Indeed, our own study reveals potential sources of bias and inconsistency concerning medical examiner data on drug-related deaths. Nonetheless, given that medical examiner reports provide valuable information not easily available elsewhere, the CCENDU has adopted drug overdose deaths as investigated by medical examiners to be one of its key indicators for surveillance purposes. The CCENDU's real challenge now is to work toward the improvement of medical examiner information in Canada as an accurate and reliable source of surveillance data.

Acknowledgements

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Book Reviews

Asthma Epidemiology: Principles and Methods

By Neil Pearce, Richard Beasley, Carl Burgess and Julian Crane
New York: Oxford University Press, 1998;
ISBN 0-19-508016-5; $73.95 (CAN)

Overall, this is a very good textbook on the epidemiology of asthma, with only a few omissions of content. The authors come from the Wellington Asthma Research Group of Wellington, New Zealand. Readers familiar with the historical epidemiology of asthma will recall the many published studies of the sharp rises in asthma mortality in New Zealand—first in the 1960s, then the 1980s—and the epidemiologic identification of the most likely causes (more about that below). The authors themselves are well published in the field, and they are cited in this textbook along with many other well-known authors of epidemiologic studies of asthma in the Western world.

The book is not too long to tackle: only 260 pages, including references. Although this reviewer read it from beginning to end, the book can be used as a reference because most of the chapters can be read independently as needed. Consisting of seven chapters (excluding the Introduction), the book is organized into three parts: "Basic Principles of Asthma Epidemiology," "Asthma Morbidity" and "Asthma Mortality."

Intertwined in the book are the two basic themes of asthma epidemiology. The first is the epidemiologic *evidence* that answers questions like the following: Is asthma prevalence still rising? What were the causes of the dramatic increases in mortality in the previous two decades? What is the evidence about the risk factors for asthma, including genetic and early life exposures, in causing the disorder?

The second theme is that of epidemiologic *methods*: the strengths and weaknesses of various study designs, definitions of terms, measurement issues, control of bias and confounding, and so on. These issues are, of course, generic to all epidemiologic research, but the authors here provide many examples pertinent to the study of asthma.

The book starts with a short but interesting history of the recognition of the asthmatic condition in ancient times. The word *asthma* came from the Greek word for "panting." The Introduction summarizes some international definitions of asthma, but provides only a brief description of the pathophysiology, clinical features and management of the disease. In subsequent chapters, the pathophysiologic and clinical aspects of asthma (including treatment) are discussed only in the context of epidemiologic studies. The reader who is not already familiar with the pathophysiology and clinical features may have a little more difficulty understanding the significance of the studies, aside from methodological issues.

Even a few illustrations (of the lungs and bronchi, of inflammatory cells, etc.) could make the book more accessible to the novice reader of asthma epidemiology. One would not expect colourful Frank Netter-like creations, but some small illustrations of spirometers, peak flow meters and inhaler medications might facilitate the understanding of the many epidemiologic studies concerning diagnostic and treatment issues for asthma.

However, the authors provide excellent discussions of epidemiologic study design and measurement issues in chapters 2 and 3. Measures of incidence and prevalence, selection of cases and controls, issues of precision, validity, confounding, bias and effect modification ... these are all covered comprehensively but succinctly.

Epidemiologic methods are also covered well in Chapter 4, "Measuring Asthma Prevalence." The authors "get specific" when discussing asthma symptom questionnaires, such as the large-scale European Community Respiratory Health Survey (ECRHS) and the International Study of Asthma and Allergies in Childhood (ISAAC). The pros and cons of using physiologic measures such as bronchial hyperresponsiveness are also addressed.

Another minor "deficiency" in this book is the relative brevity concerning the evidence about the recent international trends in asthma prevalence and incidence. While the evidence for asthma *mortality* trends merits the two full (and very good) chapters at the end of the book, the evidence for asthma *prevalence* trends are only briefly discussed in the Introduction, in Chapter 4 (pp 77–79) and on page 213 (in the context of whether increased prevalence or incidence was behind the increased mortality rates—short answer: not significantly).

Chapter 6 thoroughly examines both epidemiologic evidence and methods regarding the risk factors for asthma. *Risk factors* are broadly defined to include everything from genetics and demographics to atopy, allergens, air pollution, occupational exposures (sometimes omitted in asthma epidemiology literature) and even diet. The authors provide many good examples from the published literature. They not only mention study results, but also venture reasoned opinions on the overall strength of the evidence concerning certain risk factors.

As already mentioned, the last two chapters (7 and 8) review the issues of asthma mortality, both the evidence about recent international trends and the methods behind the different kinds of epidemiologic studies. Chapter 7, in particular, reads like a good "mini-detective story" about determining the causes of the epidemics of asthma mortality—first in the 1960s, then the late 1970s to the 1980s—in countries such as New Zealand, Australia, Great Britain, the United States and Canada (e.g. the studies in Saskatchewan by Spitzer et al.). The main culprit (for those of you who still don't know) was the introduction (and presumed overuse) of inhaled beta-2 agonists such as isoproterenol (the "Forte" preparation) and fenoterol.

Another bonus of this book is that each chapter closes with a good one-paragraph summary. Somewhat unfortunately, however, the book ends abruptly with the summary of the last chapter. A "closing" chapter for the book, perhaps about future epidemiologic research needs for asthma, would have been desirable.

It would also have been useful to have a chapter summarizing the state of public health surveillance of asthma, including the kinds and sources of mortality and morbidity data available in several major countries as examples. I think that this is part of *asthma epidemiology*.

But these are relatively minor quibbles about a fine textbook overall. The most suitable audiences, according to the authors, would be "not only epidemiologists, but also respiratory physicians, allergists and pediatricians involved in asthma epidemiology." I would expand this to include graduate-level students and other clinical practitioners who wanted a good review of asthma epidemiology.

Overall rating:	Very good
Strengths:	Covers issues of both epidemiologic evidence and methods pertinent to the studies of asthma References cited are up to date (to 1997) and international Very good review of study design issues, definitions of measurement terms, evidence about risk factors for asthma and investigations of the sharp rises in asthma mortality in the 1960s to 1980s
Weaknesses:	Could have more explanation of the pathophysiology, clinical features and management of the disease; a few illustrations would help Could have explained more about the evidence behind the increases in asthma prevalence (although partly addressed in the detailed chapter on the increases in asthma *mortality*)

Robert L Jin
Chief, Respiratory Disease Division
Bureau of Cardio-Respiratory Diseases and Diabetes
Laboratory Centre for Disease Control
Jeanne Mance Building, 18th Floor
Health Canada, Tunney's Pasture, AL: 1918C3
Ottawa, Ontario K1A 0K9

Applied Epidemiology: Theory to Practice

Edited by Ross C Brownson and Diana B Petitti
New York: Oxford University Press, 1998;
ISBN 0-19-511190-7; $73.50 (CAN)

The last several years have seen the publication of a number of important epidemiology textbooks, such as the new edition of *Modern Epidemiology*.[1] As a result, it was not clear to me that there was any need for a further basic epidemiology text. However, *Applied Epidemiology* is not a traditional epidemiology text. After a few brief introductory chapters on epidemiologic principles and methods, the book instead deals with the role of epidemiology in the practice of public health.

This book should help fill a void in the training of many epidemiologists who receive rigorous training in epidemiologic methods but little or no training in public health, and it will be most useful to epidemiologists working in public health departments.

The principle limitation of the book stems from its American perspective and the country-specific nature of public health practice. For example, differences in how health care is delivered in the United States versus Canada lessen the usefulness of the chapter on screening in the community to Canadian readers. The heterogeneous nature of US health care funding has meant that some sectors have embraced controversial screening strategies, such as mammography for women under age 50 and PSA screening for men, in contrast to the more conservative approach taken by the publicly funded health care system in Canada. The book should have discussed problems that result from situations in which those most likely to be screened may be those

who least need to be screened, as well as the advantages of systematic screening versus ad hoc screening.

The chapter on outbreak and cluster investigations could be stronger. Although Brownson (chapter author) acknowledges that the scientific value of community cluster investigation may be limited, he fails to fully explore the problems associated with these studies, such as those of post hoc reasoning, or to capture the skepticism that many feel for cluster investigations.

The book also deals with a number of currently "hot" topics, such as outcomes research, measuring the quality of health care and cost-benefit analysis. Although written from a US regulatory point of view, the chapter on risk assessment is particularly interesting.

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Howard I Morrison
Chief, Behavioural Risk Assessment Division
Cancer Bureau
Laboratory Centre for Disease Control
Health Canada, Tunney's Pasture, AL: 0601C1
Ottawa, Ontario K1A 0L2

Abstract Reprints

1. Creating a population-based linked health database: a new resource for health services research

Richard Chamberlayne, Bo Green, Morris L Barer, Clyde Hertzman, William J Lawrence, Samuel B Sheps
***Can J Public Health** 1998;89(4):270–3*

As the availability of both health utilization and outcome information becomes increasingly important to health care researchers and policy makers, the ability to link person-specific health data becomes a critical objective. The integration of population-based administrative health databases has been realized in British Columbia by constructing an historical file of all persons registered with the health care system, and by probabilistically linking various program files to this 'coordinating' file. The linkages have achieved a high rate of success in matching service events to person-specific registration records. This success has allowed research projects to be proposed which would otherwise not have been feasible, and has initiated the development of policies and procedures regarding research access to linked data. These policies and procedures include a framework for addressing the ethical issues surrounding data linkage. With continued attention to confidentiality issues, these linked data present a valuable resource for health services research and planning.

2. The epidemiology of cocaine and opiate abuse in urban Canada

Christiane Poulin, Pamela Fralick, Elisabeth M Whynot, Nady el-Guebaly, Dave Kennedy, Joyce Bernstein, Denis Boivin, Joseph Rinehart
***Can J Public Health** 1998;89(4):234–8*

This study describes the epidemiology of cocaine and heroin abuse in urban Canada as part of an initial report on a national substance abuse surveillance system, the Canadian Community Epidemiology Network on Drug Use. Data pertaining to prevalence of use, law enforcement, treatment, morbidity and mortality of cocaine and heroin were obtained from the appropriate health and law enforcement institutions in six sentinel cities: Vancouver, Calgary, Winnipeg, Toronto, Montreal and Halifax. Cocaine and heroin appear to be more available in Vancouver than in the remaining cities. In all CCENDU cities, large proportions of persons in treatment programs for substance abuse identified cocaine as their major addiction; however, there is considerable variation in treatment utilization regarding heroin. Vancouver ranks first in terms of the per capita number of cocaine and heroin-related hospital separations and mortality rate. Cocaine abuse appears to be an emerging problem in Calgary, Winnipeg and Halifax, and opiate abuse appears to be an emerging problem in Calgary.

3. Recent findings from the Ontario Student Drug Use Survey

Edward M Adlaf, Frank J Ivis
***Can Med Assoc J** 1998;159(5):451–4*

Background: Every 2 years, the Addiction Research Foundation of Ontario, a division of the Centre for Addiction and Mental Health, sponsors the Ontario Student Drug Use Survey. The results of the surveys conducted in 1995 and 1997 are presented here and compared with results from the early 1990s.

Methods: Questionnaires were completed by 3870 and 3990 Ontario public school students enrolled in grades 7, 9, 11 and 13 in 1995 and 1997 respectively. The outcome measures were prevalence of use of 20 types of drugs and other substances, including alcohol, tobacco and prescription drugs, over the previous 12 months.

Results: For several drugs the prevalence of use in the previous 12 months had increased from 1993 to 1995, but from 1995 to 1997 there was a significant increase for only one type (hallucinogens such as mescaline and psilocybin). The inhalation of glue declined, and the use of the other 18 types of drugs remained stable.

Interpretation: Recent data suggest that increases in adolescent student drug use reported earlier this decade have not continued. However, the stability in rates of drug use is not a justification for complacency in this important area of public health.

4. Screening for prostate cancer: estimating the magnitude of overdetection

Maurice McGregor, James A Hanley, Jean-François Boivin, Richard George McLean
***Can Med Assoc J** 1998;159(11):1368–72*

Background: No randomized controlled trial of prostate cancer screening has been reported and none is likely to be completed in the near future. In the absence of direct evidence, the decision to screen must therefore be based on estimates of benefits and risks. The main risk of screening is overdetection — the detection of cancer that, if left untreated, would not cause death. In this study the authors estimate the level of overdetection that might result from annual screening of men aged 50–70.

Methods: The annual rate of lethal screen-detectable cancer (detectable cancer that would prove fatal before age 85 if left untreated) was calculated from the observed prostate cancer mortality rate in Quebec; the annual rate of all cases of screen-detectable prostate cancer was calculated from 2 recent screening studies.

Results: The annual rate of lethal screen-detectable prostate cancer was estimated to be 1.3 per 1000 men. The annual rate of all cases of screen-detectable prostate cancer was estimated to be 8.0 per 1000 men. The estimated case-fatality rate among men up to 85 years of age was 16% (1.3/8.0) (sensitivity analysis 13% to 22%).

Interpretation: Of every 100 men with screen-detected prostate cancer, only 16 on average (13 to 22) could have their lives extended by surgery, since the prostate cancer would not cause death before age 85 in the remaining 84 (78 to 87).

5. Factors associated with seat belt use: an evaluation from the Ontario Health Survey

Vic S Sahai, J Roger Pitblado, Gary W Bota, Brian H Rowe
***Can J Public Health** 1998;89(5):320–4*

This study examines the factors associated with seat belt use for drivers and passengers in Ontario. Using the 1990 Ontario Health Survey, a population-based survey of non-institutionalized Ontario residents, factors associated with seat belt use among drivers and passengers were identified and are reported as unadjusted and adjusted odds ratios (OR; 95% CI). Seat belt non-use in Ontario drivers was most strongly associated with younger age ($p < 0.0001$), high risk health behaviours (drinking and driving (OR: 2.43), speeding (OR: 2.04), smoking (OR: 1.66), being male (OR: 1.87), living in northern (OR: 1.80) or rural (OR: 1.69) regions, and achieving lower education (OR: 1.46). Seat belt non-use in passengers was associated with younger age ($p < 0.0001$), smoking (OR: 1.62), being male (OR: 1.68), living in northern (OR: 1.63) or rural (OR: 1.46) regions, and low education (OR: 1.31). Vehicular trauma is a major public health problem and seat belt use has been shown to reduce injuries in the event of a crash. Any strategy to increase seat belt use in Ontario should be targeted to involve both drivers and passengers. Attention should be paid to increasing seat belt usage by younger adults, males, and especially those living in northern and rural regions.

6. Dental amalgam and multiple sclerosis: a case-control study in Montreal, Canada

Dieudonné Bangsi, Parviz Ghadirian, Slobodan Ducic, Richard Morisset, Sébastien Ciccocioppo, Ed McMullen, Daniel Krewski
***Int J Epidemiol** 1998;27(4):667–71*

Background: The aetiology of multiple sclerosis (MS) remains poorly understood. Dental amalgams containing mercury have recently been suggested as a possible risk factor for MS.

Methods: In a case-control study conducted between 1991 and 1994, we interviewed a total of 143 MS patients and 128 controls, to obtain information on socio-demographic characteristics and the number of dental amalgams and the time since installation based on dentists' records.

Results: Neither the number nor the duration of exposure to amalgams supported an increased risk of MS. After adjustment for age, sex, smoking, and education those who had more than 15 fillings had an odds ratio (OR) of 2.57 (95% CI : 0.78–8.54) compared to those who had none; for individuals whose first amalgam was inserted more than 15 years prior to the study, we found an OR of 1.34 (95% CI : 0.38–4.72).

Conclusions: Although a suggestive elevated risk was found for those individuals with a large number of dental amalgams, and for a long period of time, the difference between cases and controls was not statistically significant.

7. Nutritional factors in the aetiology of multiple sclerosis: a case-control study in Montreal, Canada

Parviz Ghadirian, Meera Jain, Slobodan Ducic, Bryna Shatenstein, Richard Morisset
***Int J Epidemiol** 1998;27(5):845–52*

Background: It has been suggested that nutrition and food patterns, particularly high consumption of animal fat and low intake of fish products, may play a role in the aetiology of multiple sclerosis (MS).

Methods: The relation between nutritional factors and MS was studied among 197 incident cases and 202 frequency matched controls in metropolitan Montreal during 1992–1995. Dietary information was collected by employing a 164-item food frequency questionnaire in a face-to-face interview.

Results: An inverse association was observed between high body mass index (BMI) and the risk of MS, with an odds ratio (OR) of 0.76 (95% confidence interval [CI] : 0.61–0.95), per 5-unit increase in BMI, both sexes combined. In addition, taller women showed a greater risk for MS; the OR per 10 cm increase in height was 1.58 (95% CI : 1.06–2.35). In continuous variable analysis, using the difference between the lowest and highest quartile of intake as a unit, a positive association was observed with energy and animal fat intake. The OR per 897 kcal increase was 2.03 (95% CI : 1.13–3.67) and 1.99 (95% CI : 1.12–3.54) per 33 g of animal fat intake above the baseline. A significant protective effect was observed with other nutrients, including vegetable protein, dietary fibre, cereal fibre, vitamin C, thiamin, riboflavin, calcium, and potassium. Similar trends were seen for males and females when analysed separately. With respect to specific foods (as opposed to nutrients), a higher intake of fruit juices was inversely associated with risk (OR = 0.82; 95% CI : 0.74–0.92). A protective effect was also observed with cereal/breads intake for all cases combined (OR = 0.62; 95% CI : 0.40–0.97) and for fish among women only; pork/hot dogs (OR = 1.24; 95% CI : 1.02–1.51) and sweets/candy (OR = 1.29; 95% CI : 1.07–1.55) were positively associated with risk.

Conclusion: The study generally supports a protective role for components commonly found in plants (fruit/vegetables and grains) and an increased risk with high energy and animal food intake.

8. Physical activity, physical fitness and risk of dying

Paul J Villeneuve, Howard I Morrison, Cora L Craig, Douglas E Schaubel
***Epidemiology** 1998;9(6):626–31*

We examined the relation between physical activity, physical fitness, and all-cause mortality in a national population-based study of Canadians. We followed men and women ages 20–69 years who had participated in the Canada Fitness Survey between 1981 and 1988. We assessed risk factors for 6,246 men and 8,196 women using multivariate Poisson regression analysis. At baseline, all subjects were asymptomatic according to self-reported screening questions for cardiovascular disease. Men who expended ≥0.5 kilocalories per kilogram of body weight per day (KKD) experienced a 20% decline in risk of mortality [rate ratio (RR) = 0.82; 95% confidence interval (CI) = 0.65–1.04] when compared with subjects expending <0.5 KKD. We observed a 30% decline in risk of mortality among women expending ≥3.0 KKD relative to those expending <0.5 KKD (RR = 0.71; 95%

CI = 0.45–1.11). Similar patterns of risk were evident for both men and women when analyses were restricted to participation in nonvigorous activities. Those who perceived themselves to be of less than average fitness were at increased risk of mortality (male RR = 1.64, 95% CI = 1.21–2.22; female RR = 1.66, 95% CI = 1.21–2.26). Subjects with undesirable cardiorespiratory fitness levels were more likely to die, compared with those having recommended fitness levels (RR = 1.52; 95% CI = 0.72–3.18). Fifty-three per cent of men and 35% of women reported participating in a vigorous activity. The relation between daily energy expenditure and risk of mortality in these subjects could not be evaluated, as there were few deaths. Nonetheless, our results among participants reporting no vigorous activities support the hypothesis that there is a reduction in mortality risk associated with even modest participation in activities of low intensity.

9. The impact of excluding non-leisure energy expenditure on the relation between physical activity and mortality in women

Iris Weller, Paul Corey
***Epidemiology** 1998;9(6):632–5*

The purpose of this study was to examine the relation between physical activity and mortality in a 7-year follow-up of a sample of women more than 30 years of age (N = 6,620) from the Canada Fitness Survey cohort, which was initiated in 1981. Age-adjusted relative risks relating quartiles of average daily energy expenditure (kilocalories per kilogram of body weight per day) to mortality were estimated using logistic regression. Compared with the least active, the risk of all-cause mortality was 0.73 for those in the highest quartile (*P* for trend = 0.03). The associations were stronger for cardiovascular disease mortality (odds ratio = 0.51; *P* for trend = 0.01) and fatal myocardial infarction (odds ratio = 0.61; *P* for trend = 0.04) for those in the highest quartile. These relations were due mainly to the contribution of non-leisure (household chores) energy expenditure, which represented, on average, 82% of women's total activity. The accompanying study on the same cohort by Villeneuve *et al* reported estimates based on a subset of leisure-time physical activity only, which underestimates the activity of many women [CDIC Abstract Reprint No 8]. The resulting bias illustrates the importance of including non-leisure energy expenditure in the assessment of total activity. These data support the hypothesis that physical activity is inversely associated with risk of death in women.

10. Estimation of test sensitivity and specificity when disease confirmation is limited to positive results

Stephen D Walter
***Epidemiology** 1999;10(1):67–72*

Estimation of sensitivity and specificity for diagnostic or screening tests usually requires independent confirmation of subjects as diseased or nondiseased using a gold standard. In practice, however, application of the confirmatory procedure is usually limited to individuals with one or more positive test results. For situations in which two initial tests are applied, recent literature has shown that one can use the data from confirmed disease cases to estimate the ratio of test sensitivities and the information from confirmed noncases to estimate the ratio of false-positive rates. In this paper, I show that estimates of sensitivity and specificity can be obtained for each test separately, together with an estimate of the disease prevalence. The only additional information required compared with previous methodology is the total number of individuals tested, a quantity that is usually readily available. The assumption that the test errors are independent is required. Although specific patterns of test errors cannot be identified, the overall assumption can be tested using goodness of fit. I illustrate the methods using data on breast cancer screening. Provision of sensitivity and specificity estimates for each test separately provide considerably greater insight into the data than previous methods.

11. The relationship between parental occupation and bone cancer risk in offspring

Lisa Hum, Nancy Kreiger, Murray M Finkelstein
***Int J Epidemiol** 1998;27(5):766–71*

Background: Bone cancers in children are serious and highly fatal conditions, yet relatively little is known about their causes or methods of prevention.

Methods: The relationship between parental occupation and bone cancer in offspring was explored in a case-control study. Cases were identified from the Ontario Cancer Registry; population-based controls were matched on sex and age. Data were collected from their parents through the use of a mailed self-administered questionnaire.

Results: The odds ratio estimates (OR) for bone cancer were elevated for fathers in the social sciences (OR = 2.5, 95% confidence interval [CI] : 0.7–8.4). Risk of Ewing's sarcoma was significantly high among children with fathers in social sciences (OR = 6.2, 95 % CI : 1.6–24.5) and mothers in teaching (OR = 3.1, 95 % CI : 1.1–8.7) or farming (OR = 7.8, 95% CI : 1.9–31.7). Osteosarcoma risk was increased for fathers in farming (OR = 2.1, 95% CI : 0.8–5.7), and mothers in managerial and administrative work (OR = 2.3, 95% CI : 0.6–8.1), and product fabricating, assembling, and repairing (OR = 2.0, 95% CI : 0.6–7.2).

Conclusions: Certain methodological problems plague studies of bone cancer in children (e.g. small studies, low statistical power, analysis of multiple occupational categories, difficulty in identifying specific carcinogenic agents). These associations require further investigation, especially as elevated risks have been reported previously for agricultural occupations.

12. Breast cancer screening programmes in 22 countries: current policies, administration and guidelines

Sam Shapiro, Elizabeth Ann Coleman, Mireille Broeders, Mary Codd, Harry de Koning, Jacques Fracheboud, Sue Moss, Eugenio Paci, Sylvie Stachenko, Rachel Ballard-Barbash, for the International Breast Cancer Screening Network (IBSN) and the European Network of Pilot Projects for Breast Cancer Screening
***Int J Epidemiol** 1998;27(5):735–42*

Background: Currently there are at least 22 countries worldwide where national, regional or pilot population-based breast cancer screening programmes have been established. A collaborative effort has been undertaken by the International Breast Cancer Screening Network (IBSN), an international voluntary collaborative effort administered from the National Cancer Institute in the US for the purposes of producing international data on the policies, funding and administration, and results of population-based breast cancer screening.

Methods: Two surveys conducted by the IBSN in 1990 and 1995 describe the status of population-based breast cancer screening in countries which had or planned to establish breast cancer screening programmes in their countries. The 1990 survey was sent to ten countries in the IBSN and was completed by nine

countries. The 1995 survey was sent to and completed by the 13 countries in the organization at that time and an additional nine countries in the European Network.

Results: The programmes vary in how they have been organized and have changed from 1990 to 1995. The most notable change is the increase in the number of countries that have established or plan to establish organized breast cancer screening programmes. A second major change is in guidelines for the lower age limit for mammography screening and the use of the clinical breast examination and breast self-examination as additional detection methods.

Conclusions: As high quality population-based breast cancer screening programmes are implemented in more countries, they will offer an unprecedented opportunity to assess the level of coverage of the population for initial and repeat screening, evaluation of performance, and, in the longer term, outcome of screening in terms of reduction in the incidence of late-stage disease and in mortality.

13. First analysis of mortality and occupational radiation exposure based on the National Dose Registry of Canada

JP Ashmore, D Krewski, JM Zielinski, H Jiang, R Semenciw, PR Band
***Am J Epidemiol** 1998;148(6):564–74*

A cohort mortality study of occupational radiation exposure was conducted using the records of the National Dose Registry of Canada. The cohort consisted of 206,620 individuals monitored for radiation exposure between 1951 and 1983 with mortality follow-up through December 31, 1987. A total of 5,426 deaths were identified by computerized record linkage with the Canadian Mortality Data Base. The standardized mortality ratio for all causes of death was 0.61 for both sexes combined. However, trends of increasing mortality with cumulative exposure to whole body radiation were noted for all causes of death in both males and females. In males, cancer mortality appeared to increase with cumulative exposure to radiation, without any clear relation to specific cancers. Unexplained trends of increasing mortality due to cardiovascular diseases (males and females) and accidents (males only) were also noted. The excess relative risk for both sexes, estimated to be 3.0% per 10 mSv (90% confidence interval 1.1–4.8) for all cancers combined, is within the range of risk estimates previously reported in the literature.

14. Immunohistochemical detection of c-erbB-2 and p53 in benign breast disease and breast cancer risk

Thomas E Rohan, Warren Hartwick, Anthony B Miller, Rita A Kandel
***J Natl Cancer Inst** 1998;90(17):1262–9*

Background: We studied the associations between c-erbB-2 protein overexpression and p53 protein accumulation in benign breast tissue and the risk of subsequent breast cancer.

Methods: We conducted a case-control study nested within the cohort of 4888 women in the National Breast Screening Study (NBSS) who were diagnosed with benign breast disease during active follow-up. Case subjects were the women who subsequently developed breast cancer (ductal carcinoma *in situ* [DCIS] or invasive carcinoma). Control subjects were matched to each case subject on NBSS study arm, screening center, year of birth, and age at diagnosis of benign breast disease. Histologic sections of benign and cancerous breast tissues were analyzed immunohistochemically. Information on potential confounding factors was obtained by use of a self-administered lifestyle questionnaire.

Results: Accumulation of p53 protein was associated with an increased risk of progression to breast cancer (adjusted odds ratio [OR] = 2.55; 95% confidence interval [CI] = 1.01–6.40), whereas c-erbB-2 protein overexpression was not (adjusted OR = 0.65; 95% CI = 0.27–1.53). The findings for c-erbB-2 and p53 did not differ among strata defined by menopausal status, allocation within the NBSS, history of breast disease, and whether the benign breast disease was detected at a scheduled screen or between screens. The results were also similar after exclusion of case subjects whose diagnosis of breast cancer occurred within 1 year of their diagnosis of benign breast disease and after exclusion of subjects with DCIS.

Conclusions: p53 protein accumulation, but not c-erbB-2 protein overexpression, appears to be associated with an increased risk of progression to breast cancer in women with benign breast disease.

Calendar of Events

March 28–30, 1999 **Calgary, Alberta**	"Putting Health Research to Work" 4th Annual HEALNet/RELAIS Conference HEALNet (Health Evidence Application and Linkage Network) is a member of the federal Networks of Centres of Excellence Program	Golden Planners Inc. Tel: (613) 241-9333 Fax: (613) 565-2173 E-mail: gpi@intranet.ca <http://hiru.mcmaster.ca/nce>
April 12–16, 1999 **Sao Paulo** **Brazil**	XVth World Congress on Occupational Safety and Health Theme: "Safety, Health and Environment — A Global Challenge" Organized by Brazil's Ministry of Labour, the International Labour Office and the International Social Security Association	Secretaria do XV Congresso Mundial Rua Capote Valente, 710 05409-002 - São Paulo - SP BRASIL <www.fundacentro.gov.br>
April 17–20, 1999 **Milwaukee, Wisconsin** **USA**	3rd International Symposium on Functional Gastrointestinal Disorders Sponsor: International Foundation for Functional GI Disorders (IFFGD)	Cathy Means CME, University of Wisconsin 2715 Marshall Court Madison, WI USA 53705 Tel: (608) 263-6637 *or* Jill Hart, IFFGD E-mail: iffgd@iffgd.org
April 26–29, 1999 **Albuquerque, New Mexico** **USA**	1999 CDC – Diabetes Translation Conference Centers for Disease Control and Prevention	Margaret R Hurd CDC, NCCDPHP, DDT 4770 Buford Hwy NE, Mailstop K-10 Atlanta, Georgia USA 30341-3724 Tel: (770) 488-5505 Fax: (770) 488-5966 E-mail: mrh0@cdc.gov
May 8–9, 1999 **Toronto, Ontario**	"Healthy People and Healthy Communities: A Canada–United States Dialogue on Best Practices in Public Health"	Carey Hill, Conference Organizer Healthy People and Healthy Communities The Canada West Foundation 550 – 630 3rd Avenue SW Calgary, Alberta T2P 4L4 Tel: (403) 264-9535 Fax: (403) 269-4776 E-mail: hill@cwf.ca
May 19–23, 1999 **Atlanta, Georgia** **USA**	2nd World Conference for Cancer Organizations Host: American Cancer Society, under the auspices of the UICC	Lee DeSandre American Cancer Society, Inc. 1599 Clifton Road NE Atlanta, GA USA 30329 Tel: (404) 329-7659 Fax: (404) 728-0133 E-mail: ldesandr@cancer.org <http://www.uicc.org/calendars>

June 5–9, 1999 **Toronto, Ontario**	AIHCCE 1999: American Industrial Hygiene Conference & Exposition "goes global"	Dr Ugis Bickis Consultants in Occupational and Environmental Health 500 – 837 Princess Street Kingston, Ontario K7L 1G8 Tel: (613) 544-1740 Fax: (613) 544-3104 E-mail: uib@phoenix-ohc.on.ca <www.aiha.org/aihce99/info.html>
June 6–9, 1999 **Winnipeg, Manitoba**	"Public Health in the New Millennium" Canadian Public Health Association 90th Annual Conference Co-sponsored by the Manitoba Public Health Association	CPHA Conference Department 400 – 1565 Carling Avenue Ottawa, Ontario K1Z 8R1 Tel: (613) 725-3769 Fax: (613) 725-9826 E-mail: conferences@cpha.ca <www.cpha.ca>
June 26–29 **Moncton, New Brunswick**	"Practice and Education of Health Professionals Responsive to the Needs of Individuals and Communities" International Francophone Conference in Health Sciences Co-sponsored by the World Health Organization Organized in conjunction with the Francophone Summit 1999	Secrétariat Conférence Acadie-Sherbrooke 1999 PO Box 946 Moncton, NB E1C 8N8 Tel: (506) 861-6341 *or* 1-800-964-7070 Fax: (506) 855-1646 E-mail: secretariat@confacadie-sherbrooke.org <www.confacadie-sherbrooke.org>
July 26–31, 1999 **Ottawa, Ontario**	2nd World Conference on Breast Cancer	World Conference on Breast Cancer 841 Princess Street Kingston, Ontario K7L 1G7 Tel: (613) 549-1118 Fax: (613) 549-1146 E-mail: brcancer@kos.net <www.brcancerconf.kos.net>
August 31–September 4, 1999 **Florence** **Italy**	"Epidemiology for Sustainable Health" 15th International Scientific Meeting of the International Epidemiological Association	Organizing Secretariat IEA Florence '99 c/o SINEDRION Via G. Marconi, 27 50131 Firenze, Italy Tel: 39-55-570502 Fax: 39-55-575679 E-mail: sinedrion@traduco.it <http://iea99.ds.unifi.it>

October 1–3, 1999 **Toronto, Ontario**	"Closing the Loop: Evidence into Health Practice, Organization and Policy" 3rd International Conference on the Scientific Basis of Health Services Sponsors: Canadian Foundation for Health Services Research, Health Canada and Medical Research Council of Canada	3rd Intl Conference on the Scientific Basis of Health Services c/o Alysone Will, CMP The Paragon Conference & Event Group Inc. 704 – 205 Richmond Street West Toronto, Ontario M5V 1V3 Tel: (416) 979-1300 Fax: (416) 979-1819 E-mail: info@paragon-conferences.on.ca <www.paragonconferences.on.ca/health99.html>
October 18–20, 1999 **Chilton, Oxfordshire** **United Kingdom**	International Workshop on UV Exposure, Measurement and Protection Sponsors: National Radiological Protection Board (NRPB), World Health Organization and International Commission on Non-Ionizing Radiation Protection	Dr Colin Driscoll NRPB (UV Workshop) Chilton, Didcot, OX11 0RQ United Kingdom Tel: 44-1235-822724 Fax: 44-1235-831600 E-mail: colin.driscoll@nrpb.org.uk <http://www.nrpb.org.uk/WHO-uv.htm>

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Mailing Address: ***Chronic Diseases in Canada***
Laboratory Centre for Disease Control
Health Canada, Tunney's Pasture
Address Locator: 0602C3
Ottawa, Ontario K1A 0L2

Telephone:
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