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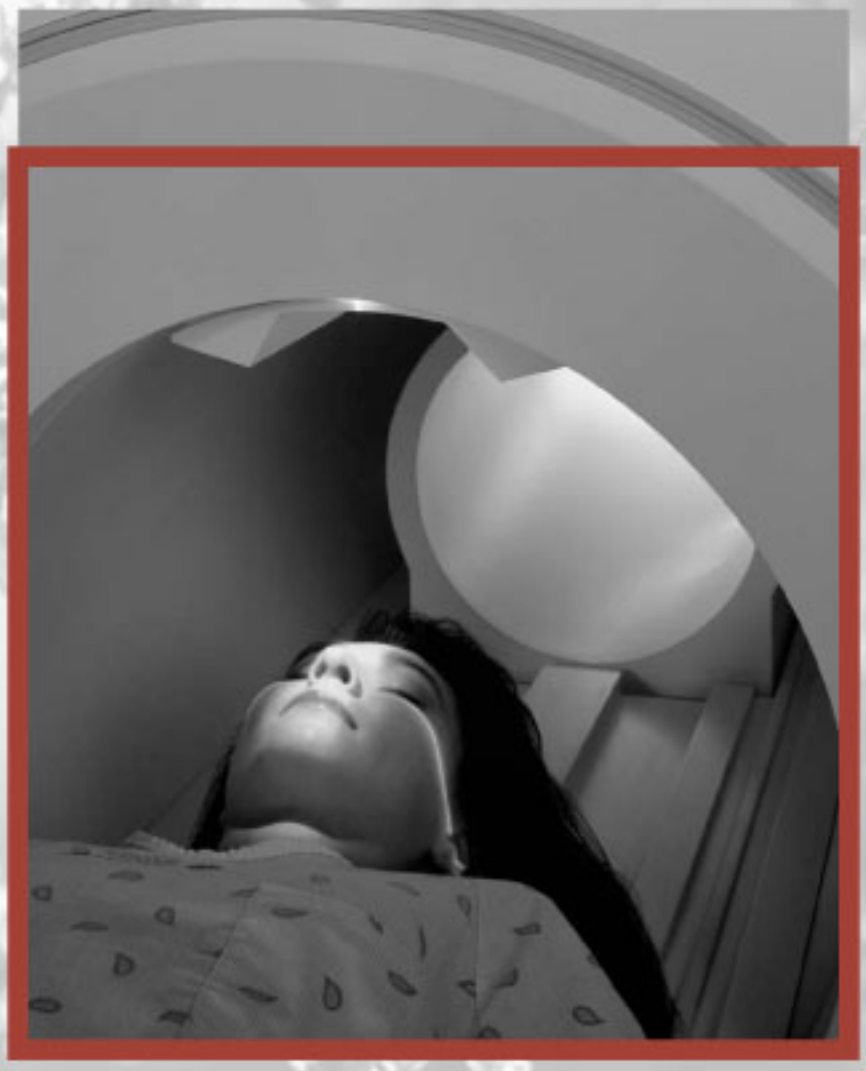

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The role of knowledge translation for cancer control in Canada

Eva Grunfeld, Louise Zitzelsberger, Charles Hayter, Neil Berman, Roy Cameron, William K Evans and Hartley Stern

Abstract

The definition and scope of cancer control has been evolving since its inception. The most recent model of cancer control in Canada has acknowledged the importance of knowledge translation to ensure that research results are implemented in practice and will be used to inform policy. However, without effort, the process of translation does not happen on a consistent basis. Knowledge translation focusses on improving the adoption of an innovation, e.g., research results. A number of health organizations in Canada have identified knowledge translation as an important activity and have begun to develop departments or initiatives dedicated to its achievement. As the emphasis in cancer control is on the application of knowledge, knowledge translation has a role to play in attaining the objectives of cancer control in Canada. It is an ideal time for the Canadian Strategy for Cancer Control and other Canadian cancer control initiatives to determine where they will locate knowledge translation in relation to their objectives.

Key words: *cancer control; knowledge translation*

Introduction

Currently accepted frameworks of cancer control emphasize the importance of applying research findings at the individual or population level towards the aim of reducing the cancer burden.[1] The literature has shown, however, that without determined efforts to disseminate and encourage adoption of research – knowledge translation – research results are not consistently integrated into practice.[2] To date, cancer control activities in Canada have been and continue to be mainly local and provincial in scope. However, since 1999, efforts have been underway to create a national strategy, the Canadian Strategy for Cancer Control (CSCC). One of the characteristics of the CSCC is a focus on research-to-policy-to-practice.[3] Research in the field of knowledge translation can make an important contribution towards realizing the goals of cancer control by encouraging the active use of research.

In this paper, we provide an introduction to cancer control in general, and its development in Canada in particular. Knowledge translation has received growing recognition as an important field in the research process. A number of Canadian initiatives, including those associated with cancer, have acknowledged knowledge translation as an important activity. The principal aim of this paper is to highlight the importance of knowledge translation to the achievement of cancer control objectives in Canada.

Cancer control

Cancer control, as defined by the National Cancer Institute of Canada (NCIC)[4] and adopted by the CSCC,[5] aims "…to prevent cancer, cure cancer, increase survival and quality of life for those who develop cancer, by converting knowledge gained through research, surveillance and outcome evaluation into strategies and actions."

The basic goal of cancer control is the "useful application of results"[6] of cancer research. Over time, cancer control has developed into a scientific field in its own right that bridges basic and applied research.[7] It covers the spectrum of activities related to cancer within a population:[3] fundamental research, interventional research, surveillance and monitoring, plus implementation (policies and program delivery) across the cancer continuum from health promotion/prevention, through screening/detection to treatment and care. Accordingly, it requires a multidisciplinary approach including involvement of biomedical, behavioural, social and population researchers; health care providers; policy-makers; administrators; educators; volunteers; patients; advocates; fund raisers; and others involved in cancer control.[6,8] The concept of cancer control is used in contradistinction to "cancer care", which is a *health care system activity*. Cancer control, on the other hand, is a *population-based activity*, which aims to ensure that developments

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in cancer control research translate into benefits for the population as a whole.[7,9]

Cancer control frameworks

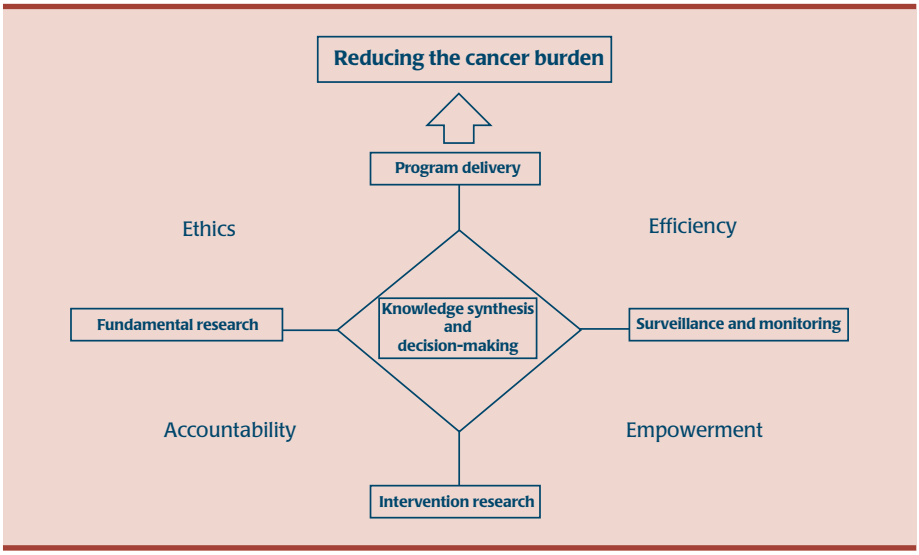
Several frameworks that capture the theoretical bases and broad spectrum of cancer control activities have been developed in the United States and Canada. The frameworks were developed to define and guide the cancer control activities[1] of initiatives at the national level. In 1984, Greenwald and Cullen published a formative paper presenting a framework to guide the cancer control research of the US National Cancer Institute.[7] Until then, the role of research in cancer control was not explicit. The focus had been on service delivery without any overt statement about the key role played by research in defining best practices for service delivery.

The Greenwald and Cullen framework[7] conceptualized cancer control activities as linear and sequential, from basic research at one end to delivery of cancer control programs to the public at the other end. While this framework did underscore the pivotal role of research in the process, it did not fully develop the complex steps from research to application. Nor did it consider the research-to-practice process as going beyond the demonstration project, and therefore, missed the important phase of knowledge translation.

More recent frameworks have captured the iterative nature of cancer control activities, highlighted the need for a multidisciplinary effort, and acknowledged the importance of knowledge translation.[1,8,10]

In 1994, the Advisory Committee on Cancer Control (ACOCC) of the NCIC published a framework intended to capture all activities that contributed to the reduction of the cancer burden in Canada[8] (see Figure 1). ACOCC's aim in developing the framework was to provide the breadth needed to encompass the NCIC's planning needs and aid in decision-making around funding priorities. Four main activities – fundamental research, interventional research, surveillance and monitoring, and program delivery – were linked to knowledge synthesis and decision-making. These activities were to operate within a set of operating principles of accountability, empowerment, ethics and efficiency.

FIGURE 1
NCIC Cancer Control Framework[8]



Most recently, the CSCC has expanded upon the framework originally developed by the NCIC (see Figure 2).[3] The analytic framework identifies the direction of knowledge flow via the various cancer control activities to actualize the "research-to-policy-to-practice" process. Knowledge translation activities take place across the cancer continuum, from promotion/prevention to treatment/care. Foundations and infrastructure include anything that acts to support the activities in the framework (for example, resources, facilities, standards, and coalitions). This is the framework the CSCC has adopted to help guide its development and implementation.

Knowledge translation

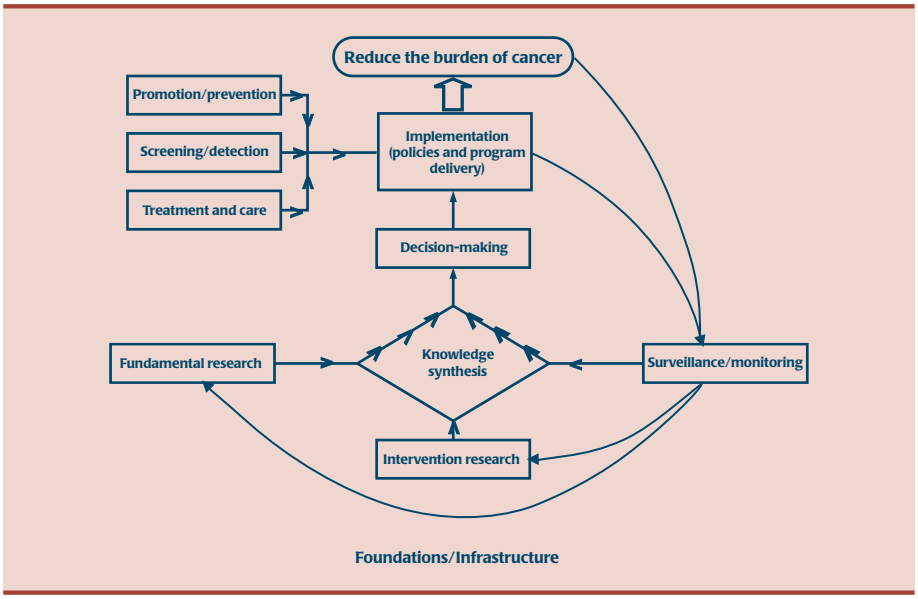
It is well recognized that the results of research are unevenly adopted in practice.[2] Recognition of this gap has focussed attention on understanding factors affecting the transfer of knowledge. Knowledge translation, as defined by the Canadian Institutes of Health Research (CIHR), is "the exchange, synthesis and ethically-sound application of research findings within a complex system of relationships among researchers and knowledge users".[11] As a relatively new discipline it lacks consistent terminology.[12] Some related terms are as follows: knowledge utilization,[13] knowledge translation,[11] knowledge transfer,[14,15] and research use.[16] These terms are sometimes clearly defined and sometimes used interchangeably.[17,18,19]

There is a growing body of research on the topic of knowledge translation relevant to health care, and two overviews of systematic reviews[20,21] have synthesized the key findings: no one intervention strategy works and no one theoretical model is fully explanatory or predictive; rather, successful translation requires multifaceted intervention strategies with different theoretical underpinnings depending on the characteristics of the environment, the innovation, and the potential adoptors.[2,17,20,22,23]

Knowledge translation models

Knowledge translation was originally seen as a linear process – if research findings were made available, it was assumed that they would be read and used.[21] However, recent literature suggests that the process is complex,[24] interactive[25] and reliant on the user's knowledge, beliefs and experiences.[17] Several models or frameworks of knowledge translation have been presented.[13,16–18,23] Most identify similar

FIGURE 2
CSCC Analytic Framework[3]



elements,[17,26] and no one model has been generally accepted as superior.[13,14,27]

The following three models are examples of those developed in Canada. The Ottawa Model of Research Use (OMRU)[16] and the CIHR model[28] are models developed within the context of health research. Landry et al.'s model[13] identifies stages outlining the process of research use in general.

The OMRU[16] is a theoretical, interdisciplinary model. Unlike less comprehensive models, it was created to encompass the key elements of the complete knowledge translation process, including its impact on health outcomes. Key elements are the characteristics of the practice environment, potential adopters, and the evidence-based innovation (e.g., evidence new to the adopter); strategies for transferring the innovation into practice, adoption and use of the innovation, and the impact of adoption – outcomes. The model is intended as a guide for policymakers concerned with the transfer of evidence-based research results into practice and for researchers studying the knowledge translation process.

Landry et al.[13] conceptualized the process of research use as a hierarchical scale called the "Ladder of Research Utilization". The higher the level achieved on the "ladder", the more successful the degree of translation. The first stage of the process is transmission, indicating that the researcher has transmitted research results to the community concerned. The second stage is cognition – the research has been read and understood. The third stage sees the research being cited as a reference by others. Efforts by practitioners and professionals to adopt the research results comprise stage four. At stage five, the results have influenced the decisions of practitioners and professionals. In the final stage, research results have been applied and extended by those concerned. Landry et al.'s research focus is on understanding what factors are involved in researchers climbing up one stage of the ladder to the next, and why some succeed while others fail.

CIHR situates knowledge translation in a different location than both the OMRU[16] and Ladder of Research Utilization.[13] Both outline activities to implement innovations (e.g., research findings) whereas CIHR initiates knowledge translation within the research cycle. Knowledge translation is seen as an integral part of the research cycle beginning with the definition of research questions and methodologies through to influencing future research according to the impact of knowledge use.[28] Within the research cycle, CIHR identifies six opportunities where there is occasion for knowledge exchange that go beyond the basic approach of publication after research. These opportunities occur at the time of definition of research questions and methodologies; while conducting research (e.g., participatory research); through publishing findings in accessible formats; by contextualizing research findings; by decision-making and taking action based on findings, and finally through influencing future research.

CIHR suggests that researchers need to be trained in the most effective approaches for knowledge exchange on the basis of how knowledge will be used. The uses to which knowledge can be applied, as identified by CIHR, include research policy-making, planning and administration, health care provision, maintenance and improvement of personal health, and commercialization.

The three models presented here each describe knowledge translation from a somewhat different perspective. Eveland recommends that the knowledge translation process be iterative and evolutionary, and that any model should be selected for its utility for a particular purpose.[14]

Knowledge translation initiatives in Canada

Recognition of the importance of knowledge translation in the research process is evidenced by the number of organizations that have identified knowledge translation as an important activity. The CIHR website[28] provides a list of resource materials that identifies university sites, local, provincial and national organizations, Canadian funding agencies, as well as US and international organizations as useful links on knowledge translation. A publication prepared in 2001 by the Canadian Population Health Initiative (CPHI) of the Canadian Institute for Health Information[29] identified 17 organizations (16 Canadian, one US) involved in health or social research and/or policy with an identified focus on knowledge translation. CPHI performed an environmental scan examining the range of strategies used by these

organizations for the transfer of research knowledge. The strategies used by these organizations were analyzed according to three criteria: target audience (who was engaged), timing (when during the research process did this engagement occur) and method (how was the target audience engaged). The scan highlighted a number of specific methods organizations can use to engage policy makers in the results of research. Taken together, the strategies used by organizations in the scan represent a valuable tool kit for CPHI and others in applying research knowledge to policies affecting the health and well-being of Canadians.

Knowledge translation and cancer control

In 1937, the US Congress defined cancer control as the "useful application of [research] results with a view to the widespread use of the most effective methods of prevention, diagnosis, and treatment".[30] This phrase captures perfectly the relation between cancer control and knowledge translation.[18] Research on the process and outcomes of knowledge translation has been recently identified as an essential part of the cancer control framework.[6,7]

From a historical perspective, the products of research have not always been well integrated with other aspects of cancer control in Canada. Early cancer control activities centred on patient care.[31] When the Canadian Medical Association discussed the form of its national cancer control strategy in the 1930s, there was much debate about whether research or education should be the main priority.[32] The Canadian Cancer Society, established in 1937, chose public and professional education as its mandate. The NCIC, which came into being approximately a decade later, decided to focus on research.[33] Thus, research was fragmented from cancer control in the early efforts to establish a national strategy.

More recently, both the NCIC framework for cancer control (see Figure 1)[8] and the analytic framework adopted by the CSCC (see Figure 2)[3] have recognized knowledge translation as an important component. The 1994 NCIC framework integrated the linear model proposed by Greenwald and Cullen into one of its main activities – interventional research. However, it took Greenwald and Cullen's work one step further. While the process described by the model began with basic research and ended with the delivery of health care programs, the NCIC framework added dissemination and adoption studies as a final step.

The expanded NCIC framework adopted by the CSCC[3] retains three of the four main activities of the framework on which it is based: interventional research, fundamental research and surveillance and monitoring. However, it differs in that decision making has been separated from knowledge synthesis and becomes an activity further along the research-to-policy-to-practice progression. Program delivery is changed to implementation and now incorporates not only program but policy delivery. Implementation is considered the final step in the cancer control process – implementing policies and programs where applicable in the cancer continuum to reduce the burden of cancer.

A recent review of how cancer control has been conceptualized in the US and Canada (e.g., through the frameworks already described above) has emphasized the need to both accelerate the translation of research into practice and "plan for, study and resource the research to practice and policy cycle".[1] Otherwise there is a danger that research efforts will continue to be poorly disseminated and adopted.

Specifically with respect to cancer initiatives in Canada, a number of organizations have added knowledge translation as a new and important activity.[1] Although it does not mention knowledge translation specifically, the CSCC has identified a research-to-policy-to-practice progression as the overall activity of its analytic framework. The Joint Advisory Committee on Cancer Control in conjunction with the Advisory Committee on Research (ACOR) of the NCIC have highlighted the translation of research to practice as one of the four top priorities for action.[34] As well, the partnership between NCIC and the Canadian Cancer Society has led to the funding of initiatives such as the Canadian Tobacco Control Research Initiative, the Centre for Behavioural Research and Program Evaluation, and the Sociobehavioural Cancer Research Networks, all of which focus on the links between research and application.[1]

The CSCC model as a knowledge translation vehicle is not specific to cancer control. The concept and organizational structure is applicable to any disease site or health issue, however, the practical implementation is more easily achieved in the cancer control sector due to pre-existing dedicated government (e.g., cancer agencies), non-governmental (e.g., NCIC) and professional (e.g., Canadian Association of PsychoOncology) entities that all share a common goal. Such a vehicle is achievable in any area where the knowledge creators and synthesizers (researchers, academics) and knowledge implementers (service providers such as cancer agencies), can be brought together to address common goals.

Relevance of knowledge translation to cancer control in Canada

A role for knowledge translation is implicit within the NCIC definition of cancer control – the conversion of knowledge gained into strategies and actions to reduce the cancer burden.[4] Miller[35] has identified a number of strategies implemented at the policy and practice levels that have begun to have an impact on trends in cancer incidence and mortality in Canada, e.g., tobacco control policies affecting lung cancer, and dietary modification affecting colorectal cancer. Prevention strategies are thought to be the biggest priority for the future.

While fundamental and clinical research continues to add to the control of cancer, there is increased recognition of the impact of behavioural and social factors, and of the need for research in these areas.[1,6] Coinciding with this recognition is a focus of

recent research interest on knowledge translation of behavioural factors that influence the adoption of innovations.[36–38]

The CSCC, as a national level broad-based initiative, has an opportunity to act in Canada as a key agent[10] responsible for knowledge translation with respect to cancer control. While the CSCC has identified six areas of priority for action (Standards; Guidelines; Primary Prevention; Rebalancing Focus; Human Resource Planning; and Strategic Research), identifying specific activities to be carried out within each of these priorities and ways in which they will be implemented and evaluated is at an early stage. It is an ideal time for the CSCC to determine where it will locate knowledge translation in relation to its objectives. Ho et al.[39] stated that knowledge translation includes the application of research findings to practice on at least three levels: the practices of health professionals (and we would add, to the practices of the population), policy-making by health authorities and governments; and implementation of strategies to enable health professionals and policy makers to work together to put policies into practice. The challenge for the CSCC, and all cancer control and cancer research initiatives in Canada, is to consider how they will actualize knowledge translation on each of these levels.

Conclusion

Despite the knowledge gains made by research with respect to cancer control, there remains a gap between what is known and what is practised across the entire spectrum of cancer control activities.[6] Translation of research knowledge has been identified as one of the key phases of cancer control.[5,6] Knowledge translation is a new and evolving field, the importance of which is beginning to be recognized by cancer control initiatives in Canada.

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Occupational exposure to chemical and petrochemical industries and bladder cancer risk in four western Canadian provinces

Anne-Marie Ugnat, Wei Luo, Robert Semenciw, Yang Mao and The Canadian Cancer Registries Epidemiology Research Group

Abstract

Occupational factors have been proposed to play a critical role in bladder cancer. This population-based case-control study was conducted to confirm the association between selected occupational and non-occupational risk factors and risk of bladder cancer using data collected from the four western Canadian provinces. Unconditional logistic regression analyses were based on 549 histologically confirmed bladder cancer cases and 1,099 controls. Bladder cancer risk was found to increase with increasing pack-years of cigarette smoking with an odds ratio (OR) in the highest quartile of 3.32 (95% confidence interval [CI], 2.28–4.82). A dose-response relationship was demonstrated between bladder cancer and pack-years of smoking ($p < 0.0001$). A positive trend was observed with coffee consumption in men ($p < 0.0001$), with the highest risk in the highest category of exposure: drinkers of four cups or more per day had an OR of 1.77 (95% CI 1.11–2.82). Increased bladder cancer risk was associated with self-reported exposure at work to several chemicals: asbestos (OR 1.69 [95% CI 1.07–2.65]); mineral, cutting or lubricating oil (1.64 [95% CI 1.06–2.55]); benzidine (2.20 [95% CI 1.00–4.87]). The population attributable fraction (PAF) estimates were 51% for cigarette smoking, 17% for heavy coffee consumption, 10% for mineral, cutting or lubricating oil exposure, 6% for asbestos exposure, and 1% for benzidine exposure. Although self-reported chemical exposures have important limitations, the findings are suggestive of increased risk for several associations previously reported between chemical agents or industries and risk of bladder cancer.

Key words: *bladder cancer; occupation*

Background

Bladder cancer is the fourth most frequently diagnosed cancer in Canadian men.[1] It has been estimated that 3,700 new cases will be diagnosed in 2004, corresponding to an annual rate of 23 per 100,000 Canadian men.

Environmental exposure to certain chemicals has been linked to increased risk of bladder cancer.[2–4] In industrialized countries, cigarette smoking has been identified as the most important risk factor, accounting for about 50% of bladder cancer cases in men.[5] Occupational exposure ranks second as a risk factor.[6] Many chemicals evaluated by the International Agency for Research on Cancer (IARC)[7] because of their potential carcinogenic risk to humans originate in the chemical and petrochemical industries. It is hypothesized that most chemical carcinogens affect the urothelial cells through their presence in the urine.

The National Enhanced Cancer Surveillance System (NECSS) coordinated by Health Canada provided an excellent opportunity to confirm the association between selected occupational and non-occupational risk factors and risk of bladder cancer in a large population-based Canadian sample. Because other studies have shown that, in industrialized countries, the population-attributable risk for bladder cancer associated with occupational exposure is less than 10% among women[8] compared with up to 25% among men,[9] we chose to focus our study on Canadian men.

Materials and methods

Selection of cases and controls

Developed in the mid-1990s, the NECSS used questionnaires to collect detailed risk factor information on 19 types of cancer from a nationwide sample of 20,755 recently diagnosed cancer patients and 5,039 population control subjects. It was designed to explore the relation between environmental factors and risk of cancer.[10]

From the NECSS data, we assembled all histologically confirmed incident cases of bladder cancer (International Classification of Diseases, Ninth Revision, code C67) in men aged 20 to 75 that were reported between 1994 and 1997 in the four western

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Canadian provinces (British Columbia, Alberta, Saskatchewan and Manitoba). We based our study on these provinces because the NECSS did not collect bladder cancer data in Ontario, Quebec or New Brunswick, and the remaining major Canadian chemical and petrochemical industries are located in the west.

Applying province-specific methods, representative samples of each province were accumulated to form a population control pool in the NECSS database. From this pool, control groups were selected with an age distribution (by five-year age groups) similar to that of the bladder cancer cases. In British Columbia, Saskatchewan and Manitoba, a random sample was obtained through the provincial health insurance plans, which generally cover more than 95% of the provincial populations. Random-digit dialing was used to derive the control sample in Alberta.

Data collection

Mailed self-administered questionnaires, with telephone follow-up when necessary for clarification, were used to collect information on all subjects' residential and occupational histories and on other risk factors for bladder cancer. Questions were included on demographic data, socioeconomic status, lifestyle, behaviour, diet pattern, physical activity and occupational history. Overall, response rates in the western provinces were 60% for male bladder cancer cases and 59% for controls.

Occupational exposure

The data collection questionnaire included questions on employment history. For each job held for at least 12 months, details were requested about the type of industry, main job duties, job location, title, status (full, part-time or seasonal) and duration. Subjects were also asked whether they had ever worked with any of 17 particular chemical substances for more than one year, and the total years of exposure. Occupational exposure was obtained in two ways.

a) Since only a small number of subjects reported having ever been exposed to the 17 chemical substances, all the occupational exposure variables were treated as dichotomous: ever exposed versus never exposed. Duration of occupational exposure to the chemical substances was categorized into long-term (20 years or more), medium long-term (10 to 19 years), short-term (1 to 9 years) and no exposure.

b) Standard Occupational Codes (SOCs) and Standard Industrial Codes developed by Statistics Canada[11] were coded from the job title, job duties and industry fields on the questionnaire. The following three occupational groups were defined using the first three digits of the SOC:

- chemical-unrelated occupations (e.g., clerical, sales or service)
- chemical-related occupations, but not major chemical-related industries (e.g., farming, mining)
- occupations in any of the three major chemical-related industries (i.e., metal processing, pulp and paper making or processing of chemicals, petroleum, rubber, plastic and related materials)

Years of occupation in these industries were categorized into long-term (20 years or more), medium long-term (10 to 19 years), short-term (1 to 9 years) and no exposure.

Statistical analysis

Due to the availability of information on a large number of variables, we implemented a screening process based on biological and statistical associations supported by the literature and the univariate analysis. All the variables on which the differences between cases and controls in the univariate analysis were statistically significant were included in the final multivariate analysis model.

Unconditional multiple logistic regression models (SAS software)[12] were used to estimate the odds ratios (ORs) while adjusting for potential confounders. Since different sampling methods were used in each province, the province of residence was controlled for in the univariate analysis. The multivariate analysis model included age (20–54, 55–64, 65–74), years of exposure, province of residence, education, pack-years of smoking, coffee consumption and tea consumption.

The PAF was calculated using a method presented by Bruzzi et al.,[13] which allows estimation on the basis of data from case-control studies. The calculations apply the knowledge of the OR and distribution of exposure only among cases, assuming that they are representative of all cases in the population. In addition to the total PAF, the summary attributable risk for each of the multiple factors was estimated with adjustment for the other risk factors.

Results

A total of 549 male bladder cancer cases and 1,099 male controls were included in the study. Table 1 compares cases and controls with respect to characteristics reported in the literature to be risk factors for bladder cancer. The controls were more likely to have more years of education than the cases. The risk increased with pack-years of smoking and with greater coffee consumption. A dose-response relationship was observed in men, with the highest risk in the highest category of exposure: smokers with smoking pack years of 30 or more had an OR of 3.32 (95% CI 2.28–4.82) and drinkers of four cups or more per day had an OR of 1.77 (95% CI 1.11–2.82).

Self-reported chemical exposure at work

Table 2 shows the ORs for bladder cancer based on occupational exposure to the chemical substances specifically asked about in the questionnaire. After adjusting for province of residence, pack-years of smoking, age, education, years of exposure to chemical substance, coffee consumption and tea consumption, we found significantly elevated risks of bladder cancer among subjects who reported occupational exposure to these chemical agents: asbestos (OR = 1.69, 95% CI 1.07–2.65); mineral, cutting or lubricating oil (OR = 1.64, 95% CI 1.06–2.55); and benzidine (OR = 2.20,

TABLE 1
Odds ratios associated with selected risk factors for bladder cancer, males, four western Canadian provinces, NECSS study, 1994–1997

	No. of cases		No. of controls		Adjusted odds ratio (OR) and confidence interval (CI)		
	n = 549	%	*n* = 1,099	%	OR (95% CI)*	OR (95% CI)**	*p* value for trend
Education							
< 10 years	160	29.1	247	22.5	1.00	1.00	
10–12 years	227	41.4	404	36.8	0.99 (0.76–1.30)	0.95 (0.71–1.26)	
> 12 years	162	29.5	448	40.8	0.70 (0.53–0.93)	0.79 (0.59–1.08)	
Smoking pack years†							
0	62	11.5	300	27.9	1.00	1.00	< 0.0001
1–9	59	10.9	234	21.8	1.21 (0.81–1.81)	1.15 (0.76–1.74)	
10–19	113	20.9	201	18.7	2.48 (1.73–3.57)	2.23 (1.53–3.25)	
20–29	104	19.3	136	12.6	3.17 (2.16–4.63)	2.67 (1.78–4.00)	
≥ 30	202	37.4	205	19.1	3.93 (2.78–5.56)	3.32 (2.28–4.82)	
Coffee consumption							
< 1 cup per month	34	6.2	142	13.1	1.00	1.00	< 0.0001
≥ 1 cup per month and ≤ 1 cup per day	89	16.3	263	24.2	1.24 (0.78–1.96)	1.13 (0.69–1.83)	
2–3 cups per day	214	39.1	400	36.8	1.92 (1.25–2.93)	1.56 (0.99–2.46)	
≥ 4 cups per day	210	38.4	282	25.9	2.77 (1.80–4.25)	1.77 (1.11–2.82)	
Tea consumption							0.3232
< 1 cup per month	165	30.9	336	31.3	1.00		
≥ 1 cup per month and ≤ 1 cup per day	250	46.8	475	44.2	1.04 (0.81–1.33)	1.16 (0.89–1.52)	
2–3 cups per day	85	15.9	190	17.7	0.79 (0.57–1.10)	0.91 (0.65–1.29)	
≥ 4 cups per day	34	6.4	73	6.8	0.83 (0.52–132)	0.92 (0.56–1.51)	

* Adjusted for age and province of residence.

** Adjusted for age, province, education, smoking (pack years), coffee, and tea consumption.

† Pack years = number of years smoked * average number of cigarettes smoked per day/25.

Note: Pack years was a continuous variable, and coffee consumption was a categorical variable.

95% CI 1.00–4.87). A non-significantly elevated risk was observed for men who reported exposure to the following chemical substances: dyestuffs (OR = 3.05, 95% CI 0.87–10.68); pesticides (OR = 1.50, 95% CI 0.89–2.53); herbicides (OR = 1.18, 95% CI 0.66–2.12); radiation sources (OR = 1.39, 95% CI 0.75–2.56); isopropyl oil (OR = 1.31, 95% CI 0.43–3.98); asphalt and creosote (OR = 1.30, 95% CI 0.89–1.92); and welding materials (OR = 1.11, 95% CI 0.74–1.66).

Table 3 presents adjusted ORs for bladder cancer in men in relation to their length of exposure to the chemicals studied. The risk of bladder cancer increased with increasing years of exposure to dyestuffs. The ORs were 1.1 (95% CI 0.4–2.8) for 1 to 9 years; 3.4 (95% CI 0.6–20.9) for 10 to19 years; and 4.7 (95% CI 0.9–23.8) for 20 years or more. The tests for trend were significant (p = 0.03).

SOC-grouped chemical-related industries

The results of examining occupational exposure based on SOC groups (Table 4) indicated that, compared with men who worked only in occupations unrelated to chemicals, men who had ever worked in chemical-related occupations (but not in major chemical-related industries) had a non- significantly higher risk of bladder cancer (OR = 1.20, 95% CI 0.90–1.60). Men who had ever worked in metal processing or pulp and paper making industries had a non-significantly higher risk of bladder cancer: the ORs were 1.30 (95% CI 0.55–3.30) and 2.33 (95% CI 0.75–7.25) respectively. Men who had ever worked in any of the major chemical related industries (metal processing, pulp and paper making, or petroleum-, rubber- or plastic-related industries) also showed a non-significantly higher risk of bladder cancer (OR = 1.27, 95% CI 0.65–2.47). Similar results were observed when adjusting for province of residence and age only.

TABLE 2
Chemical substance exposure and risk of bladder cancer in males, 1994–1997

	No. of cases exposed		No. of controls		
Substance†	*n* = 549	%	*n* = 1,099	%	OR (95% CI)‡
Asbestos	84	15.3	122	11.1	1.69 (1.07–2.65)
Coal tar, soot, pitch, creosote, asphalt	95	17.3	152	13.8	1.30 (0.89–1.92)
Mineral, cutting or lubricating oil	141	25.7	209	19.0	1.64 (1.06–2.55)
Benzidine	14	2.6	15	1.4	2.20 (1.00–4.87)
Dyestuffs	21	3.8	23	2.1	1.13 (0.43–2.96)
Mustard gas	8	1.5	5	0.5	3.05 (0.87–10.68)
Welding materials	145	26.4	238	21.7	1.11 (0.74–1.66)
Arsenic salts	8	1.5	13	1.2	0.94 (0.20–4.52)
Chromium salts	8	1.5	20	1.8	1.03 (0.29–3.67)
Cadmium salts	8	1.5	15	1.4	1.08 (0.43–2.70)
Isopropyl oil	16	2.9	20	1.8	1.31 (0.43–3.98)
Vinyl chloride	16	2.9	26	2.4	0.90 (0.34–2.38)
Pesticides	66	12.0	12.0	10.9	1.50 (0.89–2.53)
Herbicides	65	11.8	115	10.5	1.18 (0.66–2.12)
Radiation sources	38	6.9	76	6.9	1.39 (0.75–2.56)
Wood dust	121	22.0	271	24.7	0.81 (0.55–1.21)

† Ever exposed for more than one year.
‡ Adjusted for province, age, pack years of smoking, education, exposure years, coffee and tea consumption.
Note: Pack years was a continuous variable and coffee consumption was a categorical variable.

Population attributable fraction (PAF)

Estimation of PAF is presented in Table 5. Overall, PAF was 51% for smoking, 33% for coffee consumption, and 16% for occupational exposure to asbestos, mineral, cutting or lubricating oil, and benzidine. These three factors together explained more than 70% of bladder cancer cases in this population. The largest PAF was observed in those with 30 or more pack-years of somking (26%). Coffee consumption of four cups or more accounted for 17% of bladder cancer. The risk attributable to occupation ranged from 1.4 to 10.1%.

Discussion

In this case-control study, we found a significant positive association between risk of bladder cancer and occupational exposure of Canadian men to specific chemicals: mineral, cutting or lubricating oil, asbestos, and benzidine. It was estimated that 16% of bladder cancer could have been prevented by elimination of occupational exposure to these chemicals. Compared with men who never worked in chemical-related occupations, men who were ever employed in metal processing or pulp and paper industries, or any of the major chemical-related industries (metal processing, pulp and paper making, or petroleum processing) had a non-significantly higher risk of bladder cancer. We also confirmed that smoking and coffee consumption were significantly related to increased bladder cancer risk. The proportion of bladder cancer attributable to smoking and heavy coffee consumption were 51% and 17% respectively.

An IARC review concluded that "there is sufficient evidence from studies in humans that mineral oils (containing various additives and impurities) that have been used in occupations such as mulespinning, metal machining and jute processing are carcinogenic to humans."[14] Several bladder cancer case-control studies have noted an association between bladder cancer risk and work as a machinist, with ORs ranging from 1.5 to 5.0.[15] In our study, we also found an increased risk of bladder cancer among men with occupational exposure to mineral, cutting or lubricating oil. Prevention strategies to reduce the impact of occupational exposure to such oils should be considered. The US Department of Labour – Occupational Safety and Health Administration has established two exposure limits that may apply to cutting fluids. Employees should be exposed to no more than 5mg/m^3 of mineral oil mist for an eight hour time weighted average (TWA), and no more than 15 mg/m^3 for any particulate, as an eight hour TWA.[16]

Bladder cancer has long been known to be related to occupational exposure in the dye-producing industries.[17] We observed a dose-response relationship between num-

TABLE 3
Length of chemical substance exposure and risk of bladder cancer in males, 1994–1997

Exposure to chemicals (years)*	No. of cases $n = 549$	%	No. of controls $n = 1,099$	%	OR (95% CI)†	*p* value for trend
Asbestos						
Never exposed	462	84.2	971	88.4	1.0	0.20
1–9	42	7.7	57	5.2	1.7 (1.1–2.6)	
10–19	16	2.9	26	2.4	1.1 (0.6–2.2)	
≥ 20	19	3.5	28	2.6	1.4 (0.7–2.7)	
Coal tar, soot, pitch, creosote, asphalt						
Never exposed	445	81.1	928	84.4	1.0	0.43
1–9	54	9.8	87	7.9	1.3 (0.9–1.9)	
10–19	13	2.4	27	2.5	0.8 (0.4–1.6)	
≥ 20	20	3.6	26	2.4	1.2 (0.6–2.3)	
Mineral, cutting or lubricating oil						
Never exposed	400	72.9	873	79.4	1.0	0.02
1–9	42	7.7	68	6.2	1.6 (1.0–2.5)	
10–19	29	5.3	49	4.5	1.4 (0.8–2.3)	
≥ 20	54	9.8	81	7.4	1.3 (0.9–1.9)	
Benzidine						
Never exposed	535	97.5	1,083	98.5	1.0	0.26
1–9	6	1.1	4	0.4	2.7 (0.7–10.5)	
10–19	0	0.0	3	0.3		
≥ 20	5	0.9	5	0.5	2.7 (0.7–9.1)	
Dyestuffs						
Never exposed	526	95.8	1,075	97.8	1.0	< 0.01
1–9	7	1.3	15	1.4	1.1 (0.4–2.8)	
10–19	4	0.7	2	0.2	3.4 (0.6–20.9)	
≥ 20	6	1.1	3	0.3	4.7 (0.9–23.8)	
Mustard gas						
Never exposed	541	98.5	1,093	99.5	1.0	
1–9	2	0.4	4	0.4	0.8 (0.1–5.1)	
10–19	0	0.0	0	0.0		
≥ 20	0	0.0	0	0.0		
Welding materials						
Never exposed	383	69.8	835	76.0	1.0	0.21
1–9	45	8.2	101	9.2	1.1 (0.7–1.6)	
10–19	52	9.5	80	7.3	1.3 (0.9–1.9)	
≥ 20	0	0.0	0	0.0		
Arsenic salts						
Never exposed	541	98.5	1,085	98.7	1.0	0.16
1–9	2	0.4	10	0.9	0.9 (0.2–4.3)	
10–19	1	0.2	2	0.2	1.2 (0.1–14.1)	
≥ 20	4	0.7	3	0.1	6.6 (0.6–68.9)	
Chromium salts						
Never exposed	541	98.5	1,078	98.1	1.0	0.58
1–9	4	0.7	9	0.8	1.0 (0.2–3.6)	
10–19	1	0.2	8	0.7	0.2 (0.0–1.8)	
≥ 20	2	0.4	1	0.1	3.2 (0.2–41.0)	

TABLE 3
Length of chemical substance exposure and risk of bladder cancer in males, 1994–1997 (continued)

Exposure to chemicals (years)*	No. of cases $n = 549$	%	No. of controls $n = 1,099$	%	OR (95% CI)†	p value for trend
Cadmium salts						
Never exposed	541	98.5	1,084	98.6	1.0	0.20
1–9	0	0.0	8	0.7		
10–19	2	0.4	4	0.4	0.8 (0.1–4.4)	
≥ 20	3	0.6	1	0.1	6.8 (0.7–71.7)	
Isopropyl oil						
Never exposed	531	96.7	1,079	98.2	1.0	0.14
1–9	6	1.1	9	0.8	1.3 (0.4–3.9)	
10–19	4	0.7	6	0.6	1.1 (0.3–4.1)	
≥ 20	4	0.7	4	0.4	1.6 (0.4–6.7)	
Vinyl chloride						
Never exposed	533	97.1	1,072	97.5	1.0	0.58
1–9	8	1.5	16	1.5	0.9 (0.3–2.4)	
10–19	3	0.6	4	0.4	1.4 (0.3–6.7)	
≥ 20	2	0.4	5	0.5	0.6 (0.1–3.3)	
Pesticides						
Never exposed	434	79.1	898	81.7	1.0	0.21
1–9	29	5.3	40	3.6	1.5 (0.9–2.5)	
10–19	9	1.6	25	2.3	0.8 (0.3–1.7)	
≥ 20	22	4.0	47	4.3	0.9 (0.5–1.6)	
Herbicides						
Never exposed	451	82.2	910	82.8	1.0	0.98
1–9	22	4.0	37	3.4	1.2 (0.7–2.2)	
10–19	8	1.5	21	1.9	0.9 (0.4–2.1)	
≥ 20	27	4.9	47	4.3	1.1 (0.6–1.9)	
Radiation sources						
Never exposed	509	92.7	1,021	92.9	1.0	0.98
1–9	20	3.6	34	3.1	1.4 (0.7–2.5)	
10–19	7	1.3	12	1.1	0.9 (0.3–2.6)	
≥ 20	7	1.3	26	2.4	0.5 (0.2–1.3)	
Wood dust						
Never exposed	365	66.5	740	67.3	1.0	0.13
1–9	45	8.2	119	10.8	0.8 (0.6–1.2)	
10–19	20	3.6	53	4.8	0.8 (0.4–1.4)	
≥ 20	44	8.0	75	6.8	1.2 (0.8–1.8)	

* Ever exposed for more than one year.

† Adjusted for province, age, pack years of smoking, education, exposure years, coffee and tea consumption.

ber of years exposed to dyestuffs and bladder cancer risk in men in the present study as observed elsewhere.[17–19] The carcinogenic risk to the bladder of benzidine is well known,[20,21] and our study provides further support.

The results of epidemiological studies of bladder cancer and asbestos are inconsistent. Silverman and colleagues[22] suggested that asbestos and insulation workers may be at increased risk of bladder cancer, whereas other researchers found no association.[23,24] In our study, the higher bladder cancer risk seen among men exposed to asbestos could have occurred because the men exposed to asbestos were highly likely to have been exposed to mineral, cutting or lubricating oil (more than half of the men exposed to asbestos [118/206] also had been exposed to lubricating oil).

The PAFs of occupational exposure were estimated to be 10% for mineral, cutting or lubricating oil, 6% for asbestos and 1% for benzidine. The PAF for mineral, cutting or lubricating oil is considerably greater than asbestos and benzidine. Although the OR for mineral, cutting or lubricating oil is moderate (1.64), the frequency of occupational exposure to this substance is greater than asbestos and benzidine. We examined the SOCs of people who self-reported with occupational exposure to mineral, cutting or lubricating oil. The results indicated that 26% of men had occupations related to farming, fishing, forestry, mining and quarrying; 63% of men had occupations related to processing, machining, product fabricating, construction trades, transport equipment operating, material handling, and equipment operating.

In our study, statistically significant elevations of two- to three-fold were observed in the ORs at all smoking levels above 10 pack-years. A dose-response relationship was demonstrated between bladder cancer and pack-years of smoking. Such associations are well-documented in the literature.[25–27] Our data support an association between coffee consumption and risk of bladder cancer which is consistent with other studies.[28,29] To rule out a possibility of residual effect of smoking, coffee consumption and the risk of bladder cancer was also examined among non-smokers. A statistically significant excess risk was consistently observed for subjects having drunk more than 4 cups per day (OR = 6.17, [95% CI 1.73–21.96]). However, a recent systematic literature review has suggested that coffee and tea consumption are probably not associated with bladder cancer.[30] Coffee drinking has been studied extensively as a potential risk factor, but the inconsistency of the observed associations suggests that the relationship is either quite weak, noncausal, or dependent in a complex way on unmeasured factors.[31] The attributable risk estimates indicated 33% of bladder cancers among men could have been prevented by elimination of coffee consumption. A previous study by D'Avanzo et al.[32] found that coffee consumption was potentially responsible for 23% of bladder cancer. The possibility of recall bias cannot be discarded in our study.

The main advantage of this study is that it is population based. We were able to examine bladder cancer risk according to self-reported exposure to certain chemical substances at work and by occupational group based on SOCs. We also controlled for major bladder cancer risk factors.

The average response rates of both bladder cancer cases and controls were low (60% and 59% respectively). Since exposure information for non-respondents was not available for analysis, we could not examine whether or not systematic differences existed between respondents and non-respondents with respect to occupational exposure. Potential non-response bias might be introduced due to the low response rate.

This study only considered jobs held for more than one year, but this might be a substantial issue for people who were seasonally employed (and exposed). However, the underestimation of exposure would likely be the same for cases and controls, resulting in an OR biased towards 1.

TABLE 4
Occupations and risk of bladder cancer in Canadian males, 1994–1997

SOC groups*	No. of cases *n* = 549	%	No. of controls *n* = 1,099	%	OR (95% CI)†	OR (95% CI)‡
All chemical-unrelated occupations	114	20.8	287	26.1	1.00	1.00
Ever had chemical-related occupations, but not in major chemical-related industries	395	71.9	725	66.0	1.37 (1.06–1.77)	1.20 (0.90–1.60)
Ever had occupations in metal processing industries	9	1.6	18	1.6	1.22 (0.53–2.83)	1.30 (0.55–3.30)
Ever had occupations in pulp and paper industries	7	1.3	7	0.6	2.59 (0.86–7.79)	2.33 (0.75–7.25)
Ever had occupations in petroleum industries	6	1.1	9	0.8	1.48 (0.51–4.34)	0.99 (0.28–3.53)
Ever had occupations in any of the major chemical-related industries (metal processing, pulp and paper making or processing of petroleum, etc.)	22	4.0	34	3.1	1.56 (0.86–2.81)	1.27 (0.65–2.47)

SOC = Standard Occupational Code (from Statistics Canada)

* Ever employed for more than one year.

† Adjusted for province of residence and age.

‡ Adjusted for province, age, pack years of smoking, education, exposure years, coffee and tea consumption.

TABLE 5
Relative and attributable risks for the five risk factors of bladder cancer

Risk factor	Coding used in model	No. of cases	No. of controls	Relative risk (95% CI)	PAF %✚
Smoking pack years					51.2
0	0	62	300	1	
1 – < 10	1	59	234	1.15 (0.76–1.74)*	1.4
10 – < 20	2	113	201	2.23 (1.53–3.25)*	11.6
20 – < 30	3	104	136	2.67 (1.78–4.00)*	12
≥ 30	4	202	205	3.32 (2.28–4.82)*	26.2
Coffee consumption					32.6
< 1 cup per month	0	34	142	1	
≥ 1 cup per month and ≤ 1 cup per day	1	89	263	1.13 (0.69–1.83)†	1.8
2–3 cups per day	2	214	400	1.56 (0.99–2.46)†	14.2
≥ 4 cups per day	3	210	282	1.77 (1.11–2.82)†	16.5
Chemical					15.7
Asbestos no exposure	0	465	977	1	
Asbestos exposure	1	84	122	1.69 (1.07–2.65)‡	6.3
Mineral, cutting or lubricating oil no exposure	0	408	890	1	
Mineral, cutting or lubricating oil exposure	1	141	209	1.64 (1.06–2.55)‡	10.1
Benzidine no exposure	0	535	1084	1	
Benzidine exposure	1	14	15	2.20 (1.00–4.87)‡	1.4
All risk factors included in this table					71.3

* Adjusted for age, province, education, coffee, and tea consumption.
† Adjusted for age, province, education, and pack years of smoking.
‡ Adjusted for age, province, education, pack years of smoking, and coffee, and tea consumption.
✚ Adjusted for other risk factors included in this table.

We developed our exposure assessment methods without peer review. Because these methods were never validated, the potential for misclassification could not be quantified. Information on occupational chemical exposure was based solely on subjects' recall of contact with chemical agents selected a priori and listed on the questionnaire. We made no attempt to obtain all the job titles held by subjects to link with local exposure patterns. However, we examined the SOCs of respondents' self-reported occupational exposure to asbestos, mineral, cutting or lubricating oil, or benzidine. The results show that more than 90% of these people had ever been employed in chemical-related industries. Therefore, it is unlikely that this method introduced a strong information bias, it is very likely that it introduced exposure misclassification and caused true associations to be missed or underestimated. Self-reported exposure to chemicals at work could also introduce recall bias since people who have adverse health outcomes tend to remember and report past exposures differently than do those who did not develop such health outcomes.

We used only the first three digits of the SOC codes to determine subjects' occupations. Grouping jobs meant that people with different work duties and exposures were included in the same occupational group; this is usually expected to result in non-differential misclassification and bias of risk estimates to the null.[33]

Multiple comparison is also a concern for this study. There is a potential of generating false-positive results due to random variation. The results of this study should be interpreted with caution.

Conclusion

In conclusion, this study suggests that occupational exposure to certain chemical substances is associated with increased risk of bladder cancer. However, further investigations are needed in order to provide sufficient evidence of causal relations and to instigate preventive measures. We confirmed that chemical-related occupations pose a risk of bladder cancer in Canadian men. The findings of this investigation support an association between lifestyle factors (cigarette smoking and coffee consumption) and bladder cancer in men.

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The occurrence of abruptio placentae in Canada: 1990 to 1997

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Abstract

Abruptio placentae is a serious obstetric condition associated with an increased incidence of perinatal mortality and morbidity. Despite this, there is little information on the occurrence of abruptio placentae in Canada. The Discharge Abstract Database from the Canadian Institute for Health Information was used to identify a cohort of women who had singleton live or stillbirth deliveries in Canada between 1990 and 1997 (n = 2,162,815). Rates of abruptio placentae and abruptio placentae ending in stillbirth were examined by calendar year, province, maternal age and urban/rural status. There is a trend towards an increasing rate of abruptio placentae by year, from 10.9 (95% confidence interval [CI] 10.5–11.3) cases/1,000 deliveries in 1990 to a high of 12.1 (95% CI 11.6–12.5) cases/1,000 deliveries in 1996, while the rate ending in stillbirth remained relatively constant. The abruptio placentae rate was highest in mothers over 40 years of age and the case-fatality rate highest in those under 20. These results provide a baseline reference for rates of abruptio placentae in Canada.

Key words: *abruptio placentae; Canada; epidemiology; placenta diseases; pregnancy complications*

Introduction

Abruptio placentae, the premature separation of a normally implanted placenta before delivery, can be a serious pregnancy complication to both mother and infant. It is associated with an increased incidence of preterm delivery as well as maternal and perinatal mortality, causing between 15% and 25% of all perinatal deaths.[1–3]

The rate of abruptio placentae in North America is approximately 0.1–0.2 per 1,000 pregnancies,[4–7] but reported rates can range from 0.04–0.35/1,000.[1,3,8,9] This wide range in reported incidence rates may be explained partly by the differing criteria for diagnosing abruptio placentae as well as the increased recognition of milder forms of the event, i.e., the separation of the placenta from the uterine wall can be complete, partial, or marginal (involving only the placental margin). Complete detachment of the placenta from the uterus is more likely to result in a fetal death than partial or marginal separation,[4] while a marginal abruption may go undetected.

The primary etiology for abruptio placentae is still unknown, but several risk factors have been identified, including pre-eclampsia, pre-pregnancy hypertension, previous history of placental abruption, increased maternal age, cigarette smoking, and cocaine use.[1,3,9–11] It has also been hypothesized that the etiology for a marginal or partial abruptio placentae may differ from that of a complete abruptio placentae.[4]

Despite the potential severity of abruptio placentae, particularly in the case of stillbirth and maternal death, no data have been reported on the geographic and temporal distribution of abruptio placentae cases in Canada. The *Canadian Perinatal Health Report – 2000*, prepared by Health Canada's Bureau of Reproductive and Child Health and the Canadian Perinatal Surveillance System Steering Committee, provides information on numerous reproductive indicators.[12] Abruptio placentae, and other placental conditions such as placentae previa, are not monitored, however. Descriptive information on abruptio placentae is important in order to gain a better understanding of the event across the country. This paper describes rates of abruptio placentae, abruptio placentae ending in stillbirth and case fatality by year, province, maternal age and urban/rural residence in Canada between 1990 and 1997.

Methods

The Discharge Abstract Database, maintained by the Canadian Institute for Health Information (CIHI), was the source of abruptio placentae cases in this descriptive study. CIHI receives data from participating acute care hospitals on all inpatient separations in Canada (i.e., discharges, transfers, or death).[13] Few hospitals in

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Quebec send discharge data to CIHI; therefore data from the Province of Quebec are not included in the present study. This study does, however, include data from Manitoba, which includes slightly more than one third of hospital deliveries over the study period, and Nova Scotia, which sent more than one third of all discharge data from 1990 to 1993 and complete data for 1994 to 1997.[12,14] All deliveries were extracted from the complete set of hospital separations for the 1990 to 1997 period using Case Mix Group codes from the CIHI complexity grouping methodology for the mother's records.[13,14] Abruptio placentae cases were coded in the database using the International Classification of Diseases – Ninth Revision (ICD–9: 641.2).[15] Deliveries that are registered in the Discharge Abstract Database have a gestational age of 20 weeks or greater.

Births from the Northwest Territories and Yukon were combined into one category due to small numbers of cases. Urban and rural status was determined using the second digit of the Forward Sortation Area segment of the postal code, where '0' indicated a rural residence and all others indicated an urban residence. Observations with invalid postal codes (approximately 2% of total records in the database) were not included in the final cohort.

Rates are calculated for all abruptio placentae cases and for those abruptio placentae cases ending in stillbirth (abruptio-stillbirth). The occurrence of abruptio-stillbirth cases was analyzed separately as a proxy for a complete placental abruption, since a strong association has been shown between the degree of placental separation and fetal death.[4] Case-fatality rates were expressed as number of the abruptio-stillbirth cases per 100 total abruptio placentae cases. All data were analyzed using the Statistical Analysis System software package (version 8.0, SAS Institute, Inc., Cary, NC) and exact binomial 95% CI were calculated for all rates.

Results

The cohort of births from which rates were calculated comprised 2,162,815 hospital deliveries with singleton live births or stillbirths among nine Canadian provinces (excluding Quebec) and two territories between 1990 and 1997. Table 1 presents the rate of abruptio placentae and abruptio-stillbirth for singleton deliveries by year. Rates of abruptio placentae increased over the first six years of the study period, from 10.90 (95% CI 10.51–11.30) per 1,000 deliveries in 1990 to a high of 12.05 (11.64–12.47) cases per 1,000 deliveries in 1996. There was a slight decrease in the rate for 1997. Over the entire period of observation, the abruptio placentae rate was 11.25 (95% CI 11.1–11.4) per 1,000 singleton births. The rate of abruptio-stillbirth cases was 0.78/1,000 (95% CI 0.75–0.82) over the period and was relatively consistent across the period of observation. The case-fatality rate was approximately 7% over this time period.

The rates of abruptio placentae varied across provinces (Table 2), with rates below 8/1,000 in Newfoundland and Prince Edward Island and rates above 13/1,000 in Nova Scotia, Saskatchewan, and Yukon/North West Territories. This provincial pattern of rates was similar for abruptio-stillbirth, with the exception of Saskatchewan, which had a high rate of abruptio placentae and a moderate rate ending in stillbirth. A case-fatality rate statistically higher ($p < 0.05$) than the rest of Canada was observed in New Brunswick, and the case-fatality rate in Saskatchewan was significantly lower than that in the rest of Canada. Although the highest case- fatality rate was observed in Prince Edward Island, this was based on a small number of events and was not statistically different from the case-fatality rate for the rest of Canada ($p = 0.17$).

TABLE 1
Occurrence of abruptio placentae and abruptio-stillbirth by year in Canada*, 1990–1997

Year	No. of singleton births	Abruptio placentae rate per 1,000	Abruptio-stillbirth rate per 1,000	Case-fatality (%)
1990	270,118	10.90 (10.51–11.30)	0.71 (0.61–0.82)	6.52
1991	271,712	10.77 (10.39–11.17)	0.84 (0.74–0.96)	7.82
1992	273,979	10.59 (10.21–10.98)	0.73 (0.63–0.83)	6.86
1993	271,075	11.09 (10.70–11.49)	0.79 (0.69–0.91)	7.15
1994	271,886	11.10 (10.71–11.51)	0.82 (0.71–0.93)	7.35
1995	275,767	11.80 (11.40–12.21)	0.83 (0.72–0.94)	7.01
1996	268,929	12.05 (11.64–12.47)	0.84 (0.73–0.95)	6.94
1997	259,349	11.71 (11.30–12.14)	0.72 (0.62–0.83)	6.12
1990–1997	**2,162,815**	**11.25 (11.11–11.39)**	**0.78 (0.75–0.82)**	**6.97**

* Excludes Quebec.

TABLE 2
Occurrence of abruptio placentae and abruptio-stillbirth by province in Canada, 1990–1997

Year	No. of singleton births	Abruptio placentae rate per 1,000	Abruptio-stillbirth rate per 1,000	Case-fatality (%)
Newfoundland	48,236	7.77 (7.01–8.60)	0.60 (0.40–0.86)	7.73
Prince Edward Island	13,253	6.34 (5.06–7.84)	0.68 (0.31–1.29)	10.71
Nova Scotia	33,281	13.07 (11.88–14.35)	1.14 (0.81–1.57)	8.74
New Brunswick	67,232	8.15 (7.48–8.86)	0.74 (0.55–0.98)	9.12
Ontario	1,147,060	11.21 (11.02–11.41)	0.75 (0.70–0.80)	6.71
Manitoba	79,192	8.70 (8.07–9.37)	0.83 (0.65–1.06)	9.58
Saskatchewan	102,492	13.66 (12.96–14.39)	0.76 (0.60–0.95)	5.57
Alberta	307,491	12.31 (11.92–12.71)	0.85 (0.75–0.96)	6.90
British Columbia	355,987	11.31 (11.00–11.69)	0.82 (0.73–0.92)	7.26
Yukon and North West Territories	8,519	13.27 (10.96–15.92)	1.05 (0.48–1.99)	7.89
Canada	**2,162,815**	**11.25 (11.11–11.39)**	**0.78 (0.75–0.82)**	**6.97**

The rate of abruptio placentae is highest for mothers in the two older age groups, aged 35–39 years and aged 40 years and over (Table 3). However, the case-fatality rate is highest in women under 20 years of age (11%), and it decreases with age to 5% in those aged 40 years and over.

Table 4 presents rates by urban and rural status for abruptio placentae cases and abruptio-stillbirth. Rates of abruptio placentae are similar for urban (11.33/1,000, 95% CI 11.17–11.49) and rural (10.95/1,000, 95% CI 10.65–11.25) residence. However, case-fatality rates are higher for rural residence (7.89%) compared to urban residence (6.72%) ($p = 0.004$).

Discussion

This descriptive analysis of over two million singleton deliveries recorded in the Discharge Abstract Database indicates that the incidence of abruptio placentae in Canada was approximately 1% over the 1990–1997 period. This abruptio placentae rate is comparable to rates found in other population-based studies. A large cohort study in the US found an overall rate of 11.5/1,000 over the 1979–1987 period,[7] while in Norway, a rate of 6.6/1,000 was seen over a longer study period, from 1967–1991.[16]

The increase over time has also been observed in an earlier study. In Norway, the abruptio placentae rate in 1971 was 5.3/1,000, while in 1990, this rate rose to 9.1/1,000.[16] A study by Saftlas et al. in the US saw a similar increase, from 8.2/1,000 in 1979 to 11.5/1,000 in 1985.[7] Saftlas speculated that a change of rates such as that observed in our study may reflect a true increase in the rate of abruptio placentae, or it may result from changes in

TABLE 3
Occurrence of abruptio placentae and abruptio-stillbirth by mother's age

Year	No. of singleton births	Abruptio placentae rate per 1,000	Abruptio-stillbirth rate per 1,000	Case-fatality (%)
Under 20	141,462	11.40 (10.86–11.97)	1.25 (1.07–1.45)	10.97
20–24	413,533	10.93 (10.62–11.25)	0.89 (0.80–0.99)	8.16
25–29	733,164	10.23 (10.00–10.47)	0.64 (0.58–0.70)	6.26
30–34	625,315	11.41 (11.15–11.67)	0.70 (0.64–0.77)	6.14
35–39	218,511	13.87 (13.38–14.37)	0.97 (0.85–1.11)	7.03
40+	30,830	17.26 (15.83–18.77)	0.94 (0.63–1.35)	5.45
All Ages	**2,162,815**	**11.25 (11.11–11.39)**	**0.78 (0.75–0.82)**	**6.97**

TABLE 4
Occurrence of abruptio placentae and abruptio-stillbirth by urban and rural residence

Year	No. of singleton births	Abruptio placentae rate per 1,000	Abruptio-stillbirth rate per 1,000	Case-fatality (%)
Urban	1,692,592	11.33 (11.17–11.49)	0.76 (0.72–0.80)	6.72
Rural	470,223	10.95 (10.65–11.25)	0.86 (0.78–0.95)	7.89
All Canada*	**2,162,815**	**11.25 (11.11–11.39)**	**0.78 (0.75–0.82)**	**6.97**

* Excludes Quebec.

detecting abruptio placentae cases, i.e., an increase in partial or marginal abruptions, due to better ultrasound technology or more sensitive case definition. Similar detection changes may account for the rise in rates in Canada. However, the increase over time may also be real. The prevalence report in previous studies[1,4,9,10,17–19] of a number of the risk factors associated with abruptio placentae have been on the decline. For example, smoking rates have decreased in Canada over the past decade.[20] Live birth rates have also declined among women of reproductive age in Canada, from 61.1 per 1,000 in 1981 to 51.1 per 1,000 in 1997.[12] Although these factors were not available for analysis in our data, we speculate that the observed increased rates of abruptio placentae are attributable to other factors, including changes in ascertainment and reporting.

Our reported case-fatality rates are comparable to those reported in the US (7.1%) between 1979 and 1987;[7] however, the US study did not examine trends in this rate by year, region, or maternal age.

Factors that could account for associations between abruptio placentae rates and increased maternal age may include increased parity and prior abruptio placentae.[9] Pre-pregnancy hypertension, another risk factor for abruptio placentae,[10] also increases with age.[19] The high proportion of cases ending in a stillbirth among the youngest maternal age groups could be related to underutilization of prenatal health care services in this age group.[21]

Findings on the association between maternal age and abruptio placentae have been inconsistent in the literature. A case-control study in the US with 884 cases found no association,[3] while an Italian case-control study and a US cohort study both found significant associations, either with increasing age[11] or with maternal age greater than 35.[10] The Saftlas study on incidence of abruptio placentae in the US examined the rates of abruptio placentae by age for two specific time periods, 1979–1982 and 1983–1991, for white versus black women.[7] Rates for the first period remained relatively consistent among white women, but in the more recent period, abruptio placentae rates were highest among teenagers, at approximately 13/1,000, then dropped to 8/1,000 for women between 20–24, and finally increased to 10/1,000 and 11/1,000 for the 25–29 and 30+ age groups, respectively. A similar pattern, but at slightly lower rates, was seen among black women for the 1979–1982 period, while in the second study period, rates fell from 13/1,000 for teenagers, 12/1,000 for the 20–24 group, 11/1,000 for the 25–29 age group, and then increased to 13/1,000 for women aged 30 or older.[7] Our study reported a similar U-shaped relationship with age, with even higher rates for women over 40.

No literature was found that reported regional variations of abruptio placentae rates within a population. The variations in rates observed in several provinces in Canada could be attributable to differences in unmeasured risk factors (e.g., some environmental contaminant) or due to differences in ascertainment and reporting.

The accurate identification of abruptio placentae cases is the primary limitation in this study. The number of abruptio placentae cases is influenced by potential under-reporting of mild cases that may be less likely to be recorded in the administrative database utilized in this study. In addition, the definitive diagnosis of abruptio placentae may occur after delivery when the placenta is sent to the pathology laboratory, so information on the final diagnosis may not be available when data abstracting is conducted. This would under-estimate the abruptio placentae rate reported in our study.

However, a quality check of the data had positive findings. Wen et al. examined the CIHI database used in this study and found that the number of illogical and out-of-range values were few.[14] Furthermore, for most adverse pregnancy conditions and outcomes, including abruptio placentae, Wen et al. found the prevalence to be within a reasonable range of that reported in the literature.[14] An additional strength of the study is the very large number of births that were analyzed (n = 2,162,815) over the 1990–1997 time period, using quality data.

Thus, these study results provide a baseline reference for rates of abruptio placentae in Canada as well as those that specifically end in stillbirth. The significant variation that was identified in abruptio placentae rates and case-fatality rates according to time and maternal age underline the need for further investigation into this condition. Because abruptio placentae is related not only to stillbirth but also to perinatal death and sequelae from perinatal asphyxia, inclusion of abruptio placentae as an indicator in the Canadian

Perinatal Surveillance System should be considered to better understand the distribution of this event and to facilitate future observational investigations on the condition.

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Computer assisted telephone interviewing (CATI) for health surveys in public health surveillance: Methodological issues and challenges ahead

Bernard CK Choi

Abstract

This article describes methodological issues, challenges, and a vision for using computer assisted telephone interviewing (CATI) in a comprehensive public health surveillance system in the 21st century. Methodological issues include funding of surveys, survey frequency, sample size considerations, response rates, and types of bias to be considered in questionnaire design. Challenges include the recognition of the merits and limitations of CATI, and the potential for greater use in surveillance of public health issues in health regions requiring rapid and regular data. The vision of a CATI survey-based, rapid, flexible, cost-effective public health surveillance system is described. It is concluded that further discussion and views on improvements with regard to CATI methodological and practical issues will help build a better CATI survey-based public health surveillance system for the future.

Key words: *CATI; computer assisted telephone interviewing; methodology; public health surveillance; questionnaire bias; survey*

Introduction

In the development of methods for comprehensive public health surveillance in the 21st century,[1–3] health surveys using computer assisted telephone interviewing (CATI) play an important role.[4] CATI is a technique based on a combined use of long-standing methods, such as interview and surveys, and modern technologies, such as the telephone and the computer.[5] It is becoming the data collection method of choice in an increasing number of health surveys.[6–8] However, CATI health surveys raise methodological issues.[9–11] The question is how to move forward with CATI health surveys in public health surveillance.

This article reviews a number of methodological issues and proposes a number of strategies to tackle the challenges ahead. It describes the usefulness of the CATI method for surveys as a component of public health surveillance system. Two important concepts are proposed to stimulate further discussion and debate on a vision of a CATI survey-based surveillance: the importance of local CATI surveys in public health surveillance and the ability to generate rapid data.

Methodological issues

1. Sources of funding

An important question concerning health surveys is: Who pays for the survey?

Frequency distributions of the funding sponsors for the 67 Canadian health surveys carried out between 1950 and 1997, derived from the results of Kendall et al.,[12] indicate that the major sources of funding were the federal government (75% of the surveys), followed by the provincial government (54%) and research institutes, foundations or societies (15%) (Table 1).

Many federal government departments besides Health Canada also funded health surveys (see the "Other" category in Table 1). Local government has traditionally not played a role in funding health surveys (0%). In terms of data collection, the provincial government played a more important role (42% of the surveys) than the federal government (30%), universities (21%) and survey contractors (6%). The management role of surveys was shared by the provincial government (42% of the surveys), the federal government (34%) and the universities (24%).

It is important to identify stakeholders and funding sources for CATI surveys. Local governments are a potential funding source that traditionally has not been tapped. Methods may be developed to better coordinate the funding efforts of all levels of government and stakeholders.

2. Frequency of surveys

Another question concerning health surveys is: How frequently should a survey be conducted?

The frequency of health surveys in Canada from 1950 to 1997 ranged from four times a year (2% of the surveys) to only once (the

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TABLE 1
Canadian health surveys, 1950–1997, by sponsor, data collector and management, based on analysis of data by Kendall et al.[12]

	Survey sponsor	Data collector	Management
Federal government	50 (75%)	20 (30%)	23 (34%)
Health Canada	40 (60%)	1 (2%)	6 (9%)
Statistics Canada	9 (13%)	19 (28%)	14 (21%)
Other*	12 (18%)	0 (0%)	3 (5%)
Provincial government	36 (54%)	28 (42%)	28 (42%)
Local government	0 (0%)	1 (2%)	0 (0%)
Universities	2 (3%)	14 (21%)	16 (24%)
Research institutes, foundations, societies	10 (15%)	3 (5%)	6 (9%)
Industries	2 (3%)	0 (0%)	0 (0%)
Survey contractor	0 (0%)	4 (6%)	0 (0%)
Total**	**67 (100%)**	**67 (100%)**	**67 (100%)**

* Examples include: Agriculture, Citizenship Culture & Recreation, Communications, Consumers & Corporate Affairs, Fitness, Indian Affairs, Mortgage & Housing, National Defence, Secretary of State, Veterans Affairs.

** Numbers do not add to total because categories are not mutually exclusive, e.g., some surveys have multiple sponsors.

majority, or 61%) (Table 2). Most of the surveys collected data only once (50% of the 30 national health surveys and 70% of the 37 provincial surveys). In general, national health surveys tended to be more frequent (14% were done every year) than provincial health surveys (16% were done every five years).

Extreme survey frequency leads to the concept of continuous survey. For example, the annual sample can be spread evenly over 12 months to keep the survey going continuously. In other words, 100 interviews per month can be carried out instead of 1,200 interviews per year in a survey region. Indeed, in Cycle 1.1 of the 2000 Canadian Community Health Survey (CCHS) data were collected on a monthly basis.[13] There are many advantages of a continuous survey, such as better data quality, timeliness of data, ability to detect seasonal trends, and continuous employment of staff and interviewers, which means consistency of the data. In addition, there is no increased cost; in fact, continuous surveys may lead to a decreased expenditures through elimination of the cost of advertising positions, hiring staff, and training interviewers, etc., every time the survey is restarted.

The concept of "repeated sampling of the same population" was first described by Cochran in 1963.[14] With a dynamic population, a large survey at infrequent intervals is of limited use; a series of small samples at shorter intervals is more informative, and may be published regularly. With a population in which time changes are slow, on the other hand, an annual average taken over 12 monthly samples or four quarterly samples may be adequate. With just a slight change in the sample methodology, the survey becomes so much more versatile and informative.

3. Sample size

The next question is: What sample size is adequate?

In Canada, national health surveys have bigger sample sizes than provincial health surveys, e.g., 30% with samples of 10,000 to 19,999, versus 33% with samples of 2,000 to 2,999 (Table 3). However, given the fact that there are 10 provinces in Canada, the provincial health surveys may provide a larger coverage of the population than national health surveys.

Samples sizes are strongly affected by available funding. In Australia, the 1989 South Australia Health Omnibus Survey conducted 3,000 interviews/year[15] and the 1997–1998 New South Wales Health Survey conducted 17,000 (1,000/year per Area Health Service).[16] In the US, the 1998 US Behavioral

TABLE 2
Canadian health surveys, 1950–1997, by type and frequency, based on analysis of data by Kendall et al.[12]

Frequency of survey	National health surveys (1950–1997)	Provincial health surveys (1977–1997)	Total
Once	15 (50%)	26 (70%)	41 (61%)
Twice	3 (10%)	4 (11%)	7 (10%)
Occasional	2 (7%)	0 (0%)	2 (3%)
Every 5 years	1 (3%)	6 (16%)	7 (10%)
Every 4 years	1 (3%)	0 (0%)	1 (2%)
Every 3 years	1 (3%)	0 (0%)	1 (2%)
Every 2 years	2 (7%)	1 (3%)	3 (4%)
Every year	4 (14%)	0 (0%)	4 (6%)
4 times a year	1 (3%)	0 (0%)	1 (2%)
Total*	**30 (100%)**	**37 (100%)**	**67 (100%)**

* Each survey was counted only once; duplicate entries in the original data were eliminated.

TABLE 3
Canadian health surveys, 1950–1997, by type and sample size, based on analysis of data by Kendall et al.[12]

Sample size	National health surveys (1950–1997)	Provincial health surveys (1977–1997)
150,000–199,999	1 (3%)	0 (0%)
100,000–149,999	1 (3%)	0 (0%)
50,000–99,999	2 (7%	1 (3%)
40,000–49,999	0 (0%)	1 (3%)
30,000–39,999	3 (10%)	1 (3%)
20,000–29,999	5 (16%)	0 (0%)
10,000–19,999	9 (30%)	2 (5%)
5,000–9,999	2 (7%)	3 (8%)
4,000–4,999	2 (7%)	2 (5%)
3,000–3,999	1 (3%)	7 (19%)
2,000–2,999	2 (7%)	12 (33%)
1,000–1,999	2 (7%)	3 (8%)
Less than 1,000	0 (0%)	2 (5%)
Not reported	0 (0%)	3 (8%)
Total	**30 (100%)**	**37 (100%)**

Risk Factor Surveillance System (BRFSS) involved 120,000 participants per year (100 to 400/month per state).[17] In Canada, the 1994 National Population Health Survey (NPHS) longitudinal panel had a sample size of 17,276[18] and the 2000 CCHS had 130,000 respondents (2,000 to 42,000/year per province).[13]

It is easy to calculate sample size if one hypothesis is tested. However, it is difficult to perform sample size calculations for a CATI survey because there are usually many items of interest in the survey. Survey experience indicates that for most purposes a minimum sample size of 100 interviews per month per survey region is probably adequate.

4. Response rate

What response rate is adequate?

Most health surveys in Canada from 1950 to 1997 achieved a high response rate of 70% to 100% (Table 4). National health surveys in general had a higher response rate than provincial surveys. It has been suggested that the target response rate should be 80% or more.[19] In Canada, the 1994 NPHS had a response rate of 96%,[20] and in 1996 a response rate of 94%.[21] The 2000 CCHS had a response rate of 85%.[22]

There are ways to promote high response rates, such as by using trained interviewers and voices that encourage compliance (e.g., female), paying attention to speech pace and rhythm, and selecting the appropriate design and length of the questionnaire. There is usually a lower response to interviewers with "foreign" accents and young male interviewers. Questionnaires must be pretested for wording, order and misinterpretation of questions.

5. Questionnaire design

Choi and Pak provided a catalogue of 109 epidemiologic biases in biostatistics: literature review four, study design 31, study execution three, data collection 46, analysis 15, interpretation seven, and publication three.[23] Most of the biases (46/109 or 42%) occur in the data collection stage.

There are a number of questionnaire biases that specifically affect telephone interviews. For example, complex and lengthy questions should be avoided in a telephone interview. When the precise wording of a question changes from survey to survey, or the measurement scale for a quantity changes over surveys, the results may not be comparable. Some questions may be framed in such a manner that respondents

TABLE 4
Canadian health surveys, 1950–1997, by type and response rate, based on analysis of data by Kendall et al.[12]

Response rate	National health surveys (1950–1997)	Provincial health surveys (1977–1997)
90%–100%	3 (10%)	1 (3%)
80%–90%	8 (27%)	11 (30%)
70%–80%	7 (23%)	13 (35%)
60%–70%	2 (7%)	3 (8%)
50%–60%	0 (0%)	0 (0%)
40%–50%	1 (3%)	0 (0%)
30%–40%	0 (0%)	0 (0%)
20%–30%	0 (0%)	0 (0%)
10%–20%	0 (0%)	0 (0%)
0%–10%	0 (0%)	0 (0%)
Not reported	9 (30%)	9 (24%)
Total	**30 (100%)**	**37 (100%)**

are misled to a wrong choice (framing bias). The mindset of the respondents can affect their perception of questions, and therefore their answers. Questionnaires that are too long can induce fatigue in respondents and result in uniform and inaccurate answers (response fatigue bias). In a lengthy interview, e.g., a telephone interview that lasts for more than an hour, interviewees are unable to concentrate and give correct answers, and tend to say "yes" so as to quickly get through the interview (yes-saying bias).

Characteristics of CATI

In order to further advance the technique of CATI for public health surveillance, the merits and limitations must be fully appreciated (Table 5).

1. Merits of CATI

Interview

The interview is an efficient way to obtain a wide variety of information (compared with record searching, dosimeter reading, laboratory testing, etc.). It is the only way to obtain opinion and information on attitudes and, in many cases, it can collect information not available from other sources. An interview can target specific subgroups in the population (e.g., using surnames to identify ethnic groups).[24]

Telephone

Use of the telephone is a cost-effective method that can provide access to large samples (compared with personal interview) and instant results (compared with mailed surveys). Random digit dialing (RDD) can select reasonably random samples, by reaching unlisted numbers and recent connections. Telephone interviews can facilitate responses to sensitive questions (e.g., about sexual behaviours) as compared with personal interviews and are less likely to lead to socially desirable answers.

Computer assisted

CATI can link with a Survey Management System (SMS) to log interviewer activity, schedule repeat calls, select interviewees randomly, remove numbers from the call queue, produce operational reports, and perform automatic dialing. CATI can help interviewers to do their job more efficiently by eliminating tedious paperwork and by providing on-screen instructions. For example, the screen may display previously provided names of family members so that the interviewer can refer to them by name in follow-up questions. It can facilitate data collection by randomizing the order of questions and response options, by programming edits and consistency checks into the questionnaire and by providing automatic question skips for complex questions. The CATI technique may be especially useful if the question structure is complicated or there are many possible responses. This was the case in a survey that required information about asthma medication in terms of 486 possible combinations of drug, dose and delivery systems.[25] Furthermore, checks can be built in and an immediate warning given if a reply lies outside an acceptable range or is inconsistent with previous replies.

TABLE 5
Merits and limitations of computer assisted telephone interviewing (CATI)

	Merits	Limitations
Interview	1. Efficient way to obtain information 2. Only way to obtain opinion, information on attitudes 3. Can target specific subgroups in the population	1. Self-report is always a problem 2. The ability of persons to understand the questions 3. The ability to identify their status 4. Willingness to report their status 5 Need for data to be validated, e.g., by record searching
Telephone	1. Cost-effective 2. Provides large samples 3. Provides instant results 4. Random digit dialling can provide reasonably random sample 5. Facilitates sensitive questions	1. Not applicable if the percentage of household owning telephone is low 2. Tendency for people who stay at home to be interviewed 3. Random digit dialling may reach invalid numbers 4. Attention span problem 5. Cannot show visual aids 6. People are tired of telephone market surveys
Computer assisted	1. Can link with a SMS 2. Helps interviewers (on-screen instructions) 3. Facilitates data collection (randomizes questions, edits and consistency checks, question skips) 4. Facilitates data entry (direct entry, programmed coding)	1. Large initial cost 2. Requires specific software 3. More time to develop and test questionnaire 4. More time to train interviewers 5. Possible data entry errors (typing slips)

CATI permits direct data entry in an electronic format (reducing processing time and costs) and therefore quick data turnaround. Coding procedures can be programmed into the computer. A number of alternative coding methods are available, ranging from a simple pick list (shown on the screen) to more sophisticated coding tools that guide the selection of an appropriate code according to pre-specified rules and which require only a few letters to be typed. This not only reduces the costs of office coding, but also allows for better data quality.

2. Limitations of CATI

Interview

Self-report in any survey is a problem. First, respondents may not understand the questions. Second, they may not be able to identify their status. For example, up to 50% of people with diabetes do not know they have diabetes.[26] Third, they may not want to report their status (e.g., sexual behaviours). Data collected from interview still need to be occasionally validated by record searching.

Telephone

A telephone survey is not applicable if the percentage of households owning a telephone is low, because it can only reach those who can afford a telephone.[27] People who normally stay at home (e.g., older or retired people, or housewives) are the ones who tend to be interviewed. RDD may reach disconnected, non-household, fax or other invalid numbers. In general, respondents' concentration and patience are shorter over the telephone than in personal interview. Therefore, long blocks of text should be avoided, concepts should be relatively simple, rating scales straightforward, response alternatives short (maximum of five or six), and the interview normally should be limited to 20 minutes. Interviewers cannot show cards, life history calendars, or other tools that they need to show the respondents during the interview. A telephone survey loses personal touch and rapport compared with a personal interview. Finally, people nowadays are tired of telephone interviews, as there are already too many consumer and market surveys.

Computer assisted

CATI requires a large cost for initial set-up (hardware, software and personnel). It requires software specifically developed for the questionnaire, and more time and effort to develop and test the questionnaire. Automatic question skips can cause problems if not fully tested. More effort is needed to train interviewers to use computers. There is a possibility of data entry errors, e.g., typing slips when entering the answers. It has been found that 2.0% of recorded responses were erroneous, as compared with 1.1% when a paper-and-pencil technique was used.[28]

Discussion

To practise public health, we need information that is timely, appropriate, affordable, and accurate. There is great potential for CATI survey technology to address surveillance needs within a public health context. In this regard, the vision and framework of a rapid, flexible, cost-effective, and CATI survey-based public health surveillance system needs to be further developed and tested.[29] The feasibility of using on-going local CATI sample surveys to supplement national health surveys is worth further exploring.

Traditionally, health surveys are funded by the federal and, to a lesser extent, the provincial governments. It is important to recognize that there are shared and separate responsibilities of federal, provincial, regional and local agencies and organizations. Recent experience in Canada in the development of a Rapid Risk Factor Surveillance System (RRFSS) indicates that regional and local governments are perhaps interested in providing funding for a nation-wide local CATI-survey based surveillance system that can address regional and local needs.[30] Local CATI surveys have enormous potential within public health and health surveillance. Further exposition of their roles and their advantages would better serve that potential. In the US, work is underway to further develop a local and state level CATI survey-based surveillance system, the State and Local Area Integrated Telephone Survey, to supplement national CATI surveys.[31]

It is also necessary to place the use of local CATI surveys such as RRFSS in the context of the expensive and ambitious National Health Survey program which includes the CCHS being jointly funded by Statistics Canada, Health Canada, and the Canadian Institute for Health Information. For example, what is the added value of rapid health region data, given that official national data are now also available at the health region level but after a certain time lag? Are specialized CATI survey surveillance units within individual health regions necessarily the answer to obtaining critical information?

There is a question of CATI survey capacity at the local and regional level, even when local CATI surveys are justified. Given the complexity of setting up CATI surveys, is it practicable for regional health units to conduct their own CATI surveys? Or is it more cost-effective to employ specialized contractors to conduct local CATI surveys through a national or provincial coordination scheme?

At the local health region level, many health units do not have analytical or data processing resources. An example is the recent CCHS that collected data at the health region level. The CATI survey has great amounts of data that might be relevant to health regions, but many of them cannot access and analyze the data independently because of a lack of staff and resources, including hardware and software. However, these types of problems can be worked out through communications with the parties that have an interest in the data. Automated standard data analysis software, which produces a standard set of statistics, tables and graphs, may be helpful to the health regions in this regard.[1,29]

One must stress the importance of having an analytical plan for the data that are collected in the local CATI surveys. There should be a clear understanding of what descriptive statistics should be compiled quickly and then a plan should be in place

for more detailed analysis.[1] If the data are timely, there is a great sense of immediacy if important changes in population health are detected. Standard statistics and standard analysis protocols help to maintain the saliency and therefore the policy value of the information.

In modern society, the type of surveillance information that might be critical to the infectious disease patterns of a population is more likely to come from networks of clinicians rather than through surveys of the general client population, as in the case, for example, of West Nile virus, *E. coli* contamination of the Walkerton water supply and severe acute respiratory syndrome. Of course, this does not entirely diminish the importance of more general survey surveillance information. But does this mean that the local and national CATI surveys should be geared more towards chronic diseases and their risk factors?

Many national health surveys are conducted every year or every two years. In many situations, monthly data are shown to be desirable. For example, the CCHS, which started in 2000, is administered on a monthly basis.[13] The BRFSS has been a continuous surveillance system in the US for some years.[17] In Australia, NSW Health has converted its annual risk factor survey to a continuous collection system.[16] Despite the ongoing debate about whether data collected more frequently than annually (e.g., monthly) are needed for chronic diseases, monthly and seasonal trends in chronic disease risk factors, e.g., physical inactivity, or low intake of fruits and vegetables, are indeed observed, according to initial analysis of the 2000 CCHS and 1999 RRFSS pilot results. Monthly data can allow better and statistically more powerful detection and evaluation of the success of public health prevention and control programs and campaigns. Further data from the monthly CCHS and RRFSS should be able to clarifiy the true benefit of monthly data compared with the traditional annual or biennial data.

Sample size is a statistical question. There are formal procedures to calculate what sample size is needed to allow the reliable detection of differences from administration to administration (or between sample subgroups within a single administration).[32] However, it is very difficult to statistically estimate a sample size for CATI surveys, because there are many items of interest in the questionnaire. CATI survey sample sizes are better estimated empirically. For example, on the basis of the experience of the 1997–1998 New South Wales Health Survey,[16] the 1998 US BRFSS[17] and the 2000 Canadian CCHS[13] it seems that for most purposes a sample size of 100 interviews per month per survey region is adequate.

The complex nature of survey design and the various issues associated with surveys, such as methods to increase response rate, questionnaire design, and data collection biases, are difficult to address in a short paper like this. Moser's textbook on *Survey Methods in Social Investigation* is over 350 pages long.[33] Interested readers are referred to a number of recent textbooks on survey methods.[34–36] The important point is that one has to be careful when conducting survey operations, especially CATI.

The use of CATI has the advantage of built-in data quality feedback. However, there is a problem of data entry errors. This implies the need to design data quality checks at the entry level. The complexity of setting up CATI surveys, including extensive programming requirements and testing, needs to be carefully tackled.

Telephone surveys have a number of difficulties. Non-operating telephone banks or telephone numbers that are assigned to businesses are one problem that leads to difficulties in obtaining samples. The issue of cellular phones is emerging as a potential problem in CATI survey design because there are cases in which every member of a family has his or her own cellular phone and there may not be a conventional telephone in the household. The existence of multiple telephone numbers relating to the same household may influence the likelihood that a household would be selected to participate in the survey. Cellular phone numbers are excluded in current survey sample frames. That implies a possibility of bias in telephone samples.

CATI health surveys also face increasing difficulties in competing with telemarketing surveys for interview time and cooperation from the general public. With the increasing number of daily CATI surveys, including health and telemarketing, the response rate to any specific CATI survey will drop. Are we nearing the end of the useful life of the telephone, and therefore up CATI survey technology?

Besides CATI surveys, there are other vehicles for obtaining health information, such as routine records, registry data, and research databases. It may be time to explore, discover, or invent new data sources to supplement CATI data with regard to health information for public health and health surveillance.

CATI technology has only been in use for several decades. It has a number of advantages to be utilized, and a number of disadvantages to be minimized. Resolving the CATI methodological issues and building a CATI survey-based public health surveillance system will help us in charting a path forward in the 21st century.

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Reliability of self-reports: Data from the Canadian Multi-Centre Osteoporosis Study (CaMos)

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Abstract

Reliable questions enhance study design. We assessed the reliability of questions that gather demographic, sun exposure, reproductive history, and physical activity information. Subjects were participants in the Canadian Multicentre Osteoporosis Study (CaMos), a cohort study of Canadian adults recruited January 1996 to September 1997 in nine cities, stratified by sex, age, and location. Following personal interviews, 367 subjects were re-administered part of the questionnaire by telephone. Reliability was assessed using kappa and intra-class correlation. Reliability was excellent for employment status, reproductive history, weight and height (0.91 to 0.97), not differing greatly when stratified by age group or sex. Physical activity and sun exposure were reported with fair to good reliability (0.44 to 0.58), except for moderate activity (kappa = 0.30, 95% confidence interval 0.23, 0.37). Stratification by body mass index did not show significant differences. Many items can be reported reliably, especially those of height, weight, employment status and reproductive history, and, to a lesser extent, physical activity and sun exposure. Similar questions might be used reliably in future studies.

Key words: *data collection; questionnaire design; reliability*

Introduction

Since epidemiologic reports often rely on data collected through interviewer-administered questionnaires, it is important to determine the reliability of information obtained in this manner. The use of questions that have been proven reliable can add to the integrity of a study's results, and reliability assessments can aid in the design of subsequent questionnaires. We assessed the reliability of a number of demographic, reproductive, physical activity and sun exposure questions, items commonly explored in etiologic studies.

Developed to inform disease prevention strategies, the Canadian Multicentre Osteoporosis Study (CaMos) is a prospective cohort study that collects information on the skeletal health and risk factor exposures of a random sample of Canadian adults.[1] CaMos data were obtained through the use of questionnaires, spinal x-rays and bone density scans. While similar questions have been assessed in the literature for test-retest reliability, the intent to use these data in an applied, prevention-oriented manner, along with differences in study design, study populations, and the wording of questions necessitates an examination of the reliability of the CaMos questionnaire. The purpose of this analysis was to assess the test-retest reliability of a portion of the CaMos questionnaire using a combination of administration modes.

Materials and methods

Test subjects (recruited January 1996 to September 1997) were those individuals who participated in the personal interview portion of CaMos. Subjects were over 24 years of age, randomly chosen within households, and selected through telephone lists. Households were first contacted via introductory letter, followed by a telephone call in which a personal interview was arranged. Questionnaires collected demographic, medical history, reproductive event, and lifestyle (diet, physical activity and tobacco exposure) information.

Three to five months following original (test) interviews, subjects from three study centres (Hamilton, Toronto, Québec City) were administered the retest questionnaire over the telephone by the interviewer who conducted the test interview. Retest questionnaires included questions on height, weight, physical activity, sun exposure, and reproductive history.

Subjects were recruited until there was a minimum of 35 subjects in each stratum (as defined by study centre, age and sex). Up to six attempts were made to contact each respondent. Those who refused or could not be contacted were declared non-responders and recruitment continued with the next subject on the list of test respondents. Ethics approval for the study was obtained from the Research Ethics Board of each study centre.

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TABLE 1
Description of sample, respondents vs. non-respondents

Variable	Respondents *n*	Non-respondents *n*
Sex		
Male	150	27
Female	217	28
Age group		
45–64	184	31
65–80	183	24
Location of centre		
Hamilton	148	23
City of Québec	114	–
Toronto	105	32
Total subjects	**367 (87%)**	**55 (13%)**

Data were analyzed using SAS software.[2] To quantify the agreement between test and retest responses, statistics appropriate to the level of measurement were calculated: kappa and percent agreement for categorical, and intra-class correlation for continuous. In an attempt to explore differences between risk groups, reliability statistics were estimated within strata: age group (45–64, 65–80), sex, city, province, smoking status, family history of osteoporosis, and body mass index (< 25, 25–29, 30 +, for selected variables).

The agreement implied by the kappa statistic was quantified as follows: values below 0.40 represent poor agreement, those between 0.40 and 0.75 represent fair to good agreement, and those greater than 0.75 represent excellent agreement beyond chance.[3]

Results

Of the 422 respondents who were contacted, 367 (87%) completed the retest questionnaire. Table 1 shows the characteristics of respondents and non-respondents. Fifty-nine percent of respondents were female, and most respondents (69%) resided in Ontario. All City of Québec test participants completed the retest questionnaire. Kappa (K), percent agreement, and intra-class correlation (ICC) values for the level of agreement between test and retest are shown in tables 2–4 (stratum-specific data not shown). Table 2 displays the questions asked. Due to space limitations, actual questions are not shown in tables 3 and 4; they are, however, available from the authors.

Employment status, height and greatest adult weight were reported with excellent consistency in the total sample with reliability values ranging from 0.82 to 0.97. Excellent results for these variables were seen across strata defined by age, sex, and BMI, with the exception of those 65 years of age and older, who reported employment status with fair consistency (K = 0.46, 95% confidence interval [CI] 0.33, 0.59).

Sun exposure and physical activity reporting were fair to good across strata, with two exceptions: hours per week of moderate activity in the last year showed poor agreement (K = 0.30, 95% CI 0.23, 0.37) for the total sample and across all strata, and sun exposure at 50 years showed poor agreement in females (K = 0.39, 95% CI 0.25, 0.53). When asked about ever experiencing a 10-pound weight loss, agreement was fair to good (K = 0.52, 95% CI 0.44, 0.61).

Reproductive history information was reported with excellent consistency; K and ICC values fell between 0.91 and 0.97, findings that held true within age strata. Body mass index comparisons showed little change across three categories. As expected, all percent agreement values demonstrate higher agreement than do the results of kappa, as kappa is a statistic that corrects for chance agreement. Other analyses, stratified by location, province, family history of osteoporosis, and smoking status were performed, but there were too few respondents in each cell to derive stable estimates.

Discussion

The objective of this analysis was to assess the test-retest reliability of the survey questions in CaMos that measure sun exposure, physical activity, and reproductive history. Results demonstrate the excellent

TABLE 2
Reliability of general information

General information	Effective sample size	Reliability statistics (95% CI)	Percent agreement
What is your current employment status? (7 categories)	365	0.82[1] (0.77, 0.87)	86.6%
What was your greatest adult height?	349	0.97[2] (0.96, 0.97)	–
What was your greatest adult weight?	349	0.95[2] (0.94, 0.96)	–
Have you ever lost more than 10 lbs (other than after childbirth, one year post-partum)? (yes/no)	365	0.52[1] (0.44, 0.61)	76.2%

[1]Kappa statistics
[2]Intraclass correlation coefficient

TABLE 3
Reliability of physical activity and sun exposure variables[1]

Physical activity and sun exposure	Effective sample size	Reliability statistics[2] (95% CI)	Percent agreement
Description of activities at work (physical activity level) (4 categories)	361	0.58 (0.50, 0.65)	71.5%
Number of hours/week spent on strenuous sports in last year (6 categories)	365	0.57 (0.47, 0.68)	83.8%
Number of hours/week spent on moderate activity in last year (8 categories)?	365	0.30 (0.23, 0.37)	31.5%
Frequency of exposure to direct sun in last 12 months (4 categories)	365	0.56 (0.49, 0.64)	74.3%
Frequency of exposure to direct sun at 50 (4 categories)	234	0.44 (0.35, 0.54)	62.4%
Frequency of exposure to direct sun at 30 (4 categories)	365	0.49 (0.42, 0.55)	59.5%
Frequency of exposure to sun during childhood (4 categories)	363	0.53 (0.47, 0.59)	54.3%

[1]Actual questions are available from the authors.
[2]Kappa

reliability of height, weight and reproductive history reporting and the generally fair to good reproducibility of physical activity and sun exposure information. Results were stable across strata; reliability estimates remained similar when stratified by age group, sex and body mass index.

The level of agreement for sun exposure variables was generally fair to good in our data. Rosso et al.[4] found higher levels of consistency in sun exposure reporting, with ICC values ranging from 0.68 for outdoor work to 0.79 for leisure time outside. English et al.[5] reported excellent agreement when subjects were questioned about the amount of time they spent outdoors (ICC = 0.77, 95% CI 0.71, 0.83).

In our data, female reproductive history variables were reported with consistency. Similar results have been found in recent studies. Lin et al.,[6] and Kelly et al.[7] also found that number of pregnancies resulting in live births and age of menarche were reported with excellent consistency, and Bosetti[8] found similar values for the same variables, as well as for age at first birth.

In our analysis, height and weight were reported with consistency, an outcome that is supported by the literature. Kelly et al.[7] reported high levels of reliability for current height (ICC = 0.90) and weight (ICC = 0.87) as indicated by subjects interviewed less than one year after test interviews. Cumming and Klineberg[9] analyzed the responses of an elderly population (median age = 80 years) re-interviewed one to three months after test interviews; weight (0.97) and height (0.95) agreement both were high.

Our subjects reported with good to fair consistency on activity level at work and weekly time spent on strenuous sports in the last year, while hours per week spent on moderate activity was reported with poor consistency. It is possible that strenuous sports are played outdoors more often, and that time outdoors is more salient to respondents than is physical activity, which might explain the different kappa values for strenuous sports and moderate activity. Cumming and Klineberg[9] found that at age 50, leisure (physical) activity level (K = 0.61) and work activity (K = 0.68) were reported with fair to good reliability in their sample of the elderly. Similarly, Batty,[10] in a study of male factory workers (72% re-interviewed in 23 months or less, the remainder re-interviewed at > 23 months), found that the reliability of physical activity reporting was not high; fair to good results were obtained for overall leisure activity (K = 0.69) and overall work activity (K = 0.49). Although physical activity is likely to vary by season, this questionnaire did not collect historical

TABLE 4
Reliability of female reproductive history variables[1]

Reproductive variables	Effective sample size	Reliability statistics (95% CI)	Percent agreement
Removal of uterus (yes/no)	216	0.94[2] (0.89, 0.99)	97.2%
Removal of ovaries (3 categories)	213	0.91[2] (0.84, 0.97)	96.2%
Number of pregnancies resulting in live births	182	0.96[3] (0.94, 0.97)	–
Age at first birth	178	0.97[3] (0.96, 0.98)	–
Breast feeding of children (yes/no)	178	0.92[2] (0.86, 0.98)	96.1%
Age of first period	213	0.95[3] (0.93, 0.96)	–

[1]Actual questions are available from the authors.
[2]Kappa
[3]Intraclass correlation coefficient.

activity information, and the majority of retest interviews ($n = 224$) were completed in the winter months; as such, meaningful seasonal comparisons are not possible.

Results reported here may have been affected by the interval between test and retest, reporting errors, and differences in data collection techniques between test and retest. Although the test-retest time interval was minimal (three to five months), changes may have occurred that would alter responses. It is difficult to assess if the low reliability of variables that asked about physical activity over the last year reflects a change in level (possibly related to seasonal differences) rather than the unreliability of questions asked.[11,12] To minimize this source of error, Batty[10] asked respondents if their physical activity level changed between test and retest (separated by a period of 4–6 weeks). Kappa values were higher when those with changed activity levels were excluded. The reliability of work activity values over the last year increased from 0.49 to 0.54 when those who reported a changed activity level were excluded. Our physical activity results may have shown greater reliability had those who changed their activity level been excluded.

The results of this study may be affected by the data collection technique; interview data can be affected by interviewer-respondent dynamics, and it is also possible that the changed method between test (in-person) and retest (telephone) interviews may affect the results. Studies comparing the information obtained from different data collection strategies, however, have generally found little difference between telephone and in-person interviews,[13,14] and the high level of reliability reported for reproductive history indicates the acceptability of the data collection technique.

Results of this study demonstrate that height, weight, employment status and reproductive history questions (as asked in CaMos) can be answered reliably, as, to a lesser extent, can those which relate to physical activity and sun exposure. Using comparable questions, studies of similar populations may expect reliable data. Such questions can be used as a means of identifying and targeting high-risk individuals for prevention programs, and may also be used in a test-retest manner to assess the impact of public health interventions. It is important to note however, that it is important for each study to assess the reliability of the questions upon which its conclusions rely.

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Rates of carpal tunnel syndrome, epicondylitis, and rotator cuff claims in Ontario workers during 1997

Dianne Zakaria

Abstract

The primary objective of this research was the calculation of crude and specific rates of first-allowed, lost-time carpal tunnel syndrome (CTS), epicondylitis, and rotator cuff syndrome/tear (RCS/RCT) claims in Ontario workers during 1997. A secondary objective was to determine if results related to these diagnoses were consistent with findings for all cumulative trauma disorders affecting the specific part of upper extremity region. Rates were calculated by combining claim counts and population "at-risk" estimates derived from the Ontario Workplace Safety and Insurance Board databases and Canadian Labour Force Survey, respectively. The prevention index was used to prioritize occupations for intervention. Gender-specific rates declined as one moved proximally along the upper extremity. Similarly, female to male claim rate ratios declined from 1.61 for CTS to 0.47 for RCS/RCT. Frequently occurring highest rate and prevention index occupational categories across gender and diagnoses included "textiles, furs & leather goods" and "other machining occupations". Diagnosis-specific findings were consistent with previously reported part of upper extremity findings.

Key words: *carpal tunnel syndrome; claim rates; epicondylitis; gender differences; prevention index; rotator cuff; workers' compensation*

Introduction

Work-related cumulative trauma disorder of the upper extremity (CTDUE) claims are more costly and work disabling than traumatic upper extremity[1,2] or workers' compensation claims in general.[3–5] Additionally, diagnoses which tend to be associated with a gradual onset and have established typical symptoms and objective physical examination findings, such as carpal tunnel syndrome (CTS), epicondylitis, rotator cuff syndrome (RCS), and rotator cuff tear (RCT),[6,7] may be more costly and work disabling than less clinically defined gradual onset disorders, such as myalgia.[1,4,8] In particular, CTS appears most disabling. According to the US Bureau of Labor Statistics' release on lost-worktime injuries and illnesses in private industry during 2001, CTS had the greatest median days away from work, 25 days; followed by fractures, 21 days; and amputations, 18 days (http://www.bls.gov/iif/home.htm, released Thursday March 27, 2003).

Workers' compensation databases provide a means of surveillance for work-related CTDUE or specific diagnoses. Although many limitations in the use of workers' compensation data exist,[9] these databases provide easy access to population level data which can be used to assess costs, target research and prevention efforts, and evaluate prevention or control activities.[10–15] For example, previous research examined the rate of definite and definite + possible cumulative trauma disorder claims of the "neck & shoulder/ shoulder & upper arm", "elbow & forearm", and "wrist & hand" in Ontario Workplace Safety & Insurance Board-covered workers during the 1997 calendar year.[16] This required an extraction algorithm which used "part of body", "event or exposure", and "nature of injury" codes to classify a claim into one of three mutually exclusive categories: definite, possible, or non-CTDUE.[17] It may be that targeting clinically well defined diagnoses, which tend to be associated with a gradual onset, would provide similar information using a simpler, "nature of injury" extraction method. However, if results using the two extraction methods differ, research related to parts of the upper extremity cannot be generalized to the more costly and disabling specific diagnoses within these parts and vice versa.

Hence, the primary objective of this research was the estimation of crude and specific rates of CTS, epicondylitis, and RCS/RCT claims in Ontario Workplace Safety & Insurance Board-covered workers during the 1997 calendar year. A secondary objective was to determine if a simple extraction algorithm, which used clinically well defined diagnoses as a surrogate for part of upper extremity-specific cumulative trauma disorders, produced results consistent with a previously used, more complex cumulative trauma disorder extraction algorithm.

Material and methods

Information on gender, age, "part of body", "event or exposure", "nature of injury", and occupation for all first-allowed, lost-time claims occurring in Ontarians, aged 15 years or greater with a date of injury or disease in

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the 1997 calendar year (105,556), was obtained from the Ontario Workplace Safety and Insurance Board. A first-allowed claim is a newly registered claim for a previously unreported injury or illness deemed compensational. Lost-time refers to the loss of wages.[18]

Claims with the following Z795-96 Coding of Work Injury or Disease Information Standard "nature of injury" codes were extracted: "12410 carpal tunnel syndrome"; "17393 epicondylitis"; "17391 rotator cuff syndrome"; and "02101 rotator cuff tear". RCS and RCT claims were combined for two reasons. First, only a small number of RCS claims ($n = 24$) were present. Second, the distinction between a gradual versus sudden onset may not always be clear for RCT claims. "Event or exposure" distributions, which describe the manner in which the injury or disease was produced or inflicted by the identified source,[10] were presented by "nature of injury". Demographic information was compared across the three "nature of injury" groups using ANOVA and chi-square tests. In the presence of a statistically significant ($\alpha = 0.05$) ANOVA, Tukey's multiple comparison test was utilized to identify which groups significantly differed.

Since the Ontario Workplace Safety and Insurance Board and 1997 Canadian Labour Force Survey collected information on gender, age, and occupation, crude and specific rates were calculated by combining claim counts and population "at-risk" estimates derived from the two data sources, respectively. Population "at-risk" estimates were derived as per Zakaria et al.[19] Briefly, this involved extracting that class of worker most likely to be insured by the Ontario Workplace Safety and Insurance Board and using actual hours worked to calculate full-time equivalents (FTEs) "at-risk". Occupational categories were defined as per the 1997 Canadian Labour Force Survey, which used Statistics Canada's Standard Occupational Classification, 1980.[20] Since directly age-standardized gender, "nature of injury", and occupation-specific rates produced conclusions generally consistent with the non-standardized rates, they will not be presented.

TABLE 1
Event or exposure codes by nature of injury

	% Distribution
Carpal tunnel syndrome ($n = 1167$)	
repetitive motion, not elsewhere classified	34.45
repetitive placing, moving objects, except tools	24.94
repetitive use of tools	18.59
typing or key entry	11.40
repetitive motion unspecified	2.57
other	8.05
Epicondylitis ($n = 638$)	
repetitive placing, moving objects, except tools	35.42
repetitive motion, not elsewhere classified	32.13
repetitive use of tools	14.89
typing or key entry	4.55
repetitive motion unspecified	3.29
overexertion, not elsewhere classified	3.29
other	6.43
Rotator cuff syndrome/tear ($n = 208$)	
overexertion, not elsewhere classified	25.96
overexertion in lifting	19.23
fall to floor, walkway, or other surface	7.69
overexertion in pulling or pushing	7.21
repetitive motion, not elsewhere classified	6.25
bodily reactions & exertions, nec	5.29
repetitive placing, moving objects, except tools	4.81
struck by falling object	2.88
bodily reaction, nec	2.88
overexertion in holding, carrying	2.40
bending, climbing, crawling, reaching	2.40
other overexertion	0.96
other repetition	2.88
other traumatic	9.13

Note: NEC = not elsewhere classified.

TABLE 2
Descriptive statistics for carpal tunnel syndrome, epicondylitis, and rotator cuff syndrome/tear claims

Characteristic	CTS $n = 1167$	Epicondylitis $n = 638$	RCS/RCT $n = 208$
% Male	46.10	54.86	74.52
Age, mean years (sd)	40.66 (9.37)	40.62 (8.53)	43.95 (11.69)
median years	40.00	40.00	44.00
Age (%)			
15–24 years	4.63	3.76	3.37
25–34	21.08	20.53	20.67
35–44	40.36	42.63	27.40
45–54	25.96	27.74	28.37
55 plus	7.88	5.17	20.19
unknown	0.09	0.16	0.00

Note: Only first-allowed, lost-time claims have been considered. CTS = Carpal Tunnel Syndrome; RCS = Rotator Cuff Syndrome; RCT = Rotator Cuff Tear.

TABLE 3
Crude and gender-specific rates of carpal tunnel syndrome, epicondylitis, and rotator cuff syndrome/tear claims in Ontario employees, 1997

Syndrome	Overall	Females	Males	Female: male RR
CTS	[a]29.07 (27.31, 30.83)	37.22 (34.22, 40.21)	23.15 (21.14, 25.16)	1.61
Epicondylitis	15.89 (14.62, 17.17)	17.04 (15.04, 19.04)	15.06 (13.45, 16.67)	1.13
RCS/RCT	5.18 (4.47, 5.89)	3.14 (2.29, 3.98)	6.67 (5.61, 7.73)	0.47

Note: Only first-allowed, lost-time claims have been considered.
CTS = Carpal Tunnel Syndrome; RCS = Rotator Cuff Syndrome; RCT = Rotator Cuff Tear; RR = Relative Rate.
[a]Rate per 100,000 full-time equivalents (1 full-time equivalent = 50 wks/year * 40 hours/week = 2,000 hours) with 95 percent confidence interval (CI).

Rate standard errors were calculated according to Armitage and Berry [21] and used for approximate standard normal 95% confidence intervals (CI). Interactions between gender, age, and "nature of injury" were examined using Poisson regression.[22]

Finally, since focussing intervention efforts on the highest risk occupation will have little impact on claim numbers if the "at-risk" population is small, a prevention index was used to prioritize occupations for intervention purposes.[4] For each "nature of injury", occupational categories were ranked according to the frequency of claims and the rate of claims. The prevention index is the mean of these two ranks. For example, an occupational category that ranks first with respect to frequency of claims and rate of claims will have a prevention index equal to one making it worthy of increased attention and resources from a population, public health perspective. However, the prevention index does not provide information on the feasibility or potential success of interventions.

Results

Table 1 presents "event or exposure" codes by "nature of injury". More than 90% of CTS and epicondylitis claims were associated with repetition. Eighty percent of RCS/RCT claims were associated with non-traumatic events or exposures primarily involving overexertion and repetition. Of the 24 claims coded RCS, 21 (88%) were associated with repetition and none were traumatic.

Table 2 presents sex and age characteristics by "nature of injury". When comparing CTS, epicondylitis and RCS/RCT, the proportion of male claims increased with more proximal upper extremity diagnoses ($\chi^2 = 60.5726$, df = 2, $p < 0.0001$). Mean age significantly varied across "nature of injury" ($F = 11.53$, df = 2, 2008, $p < 0.0001$). Tukey's multiple comparison test ($\alpha = 0.05$) indicated that the mean age of RCS/RCT claimants was significantly greater than that of CTS or epicondylitis claimants.

Gender-specific claim rates (Table 3) declined as one moved proximally along the upper extremity. Similarly, the female to male rate ratio declined from 1.61 for CTS to 0.47 for RCS/RCT.

When examining age-specific rates (Figures 1 and 2), CTS and epicondylitis demonstrated a parabolic relationship between age and rate for men and women with the peak generally occurring in the 35 to 44 or 45 to 54 year age categories. For RCS/RCT, the rate generally rose with age, particularly in males aged 55+. Poisson regression using detailed gender, "nature of injury" and age-specific claim counts and "at-risk" estimates revealed significant gender*nature of injury, gender*age, and age*nature of injury interactions ($\alpha = 0.05$).

Table 4 presents those occupations with the highest rates and prevention indexes by gender and "nature of injury".

FIGURE 1
Age-specific rates of carpal tunnel syndrome (CTS), epicondylitis, and rotator cuff syndrome/tear (RCS/RCT) claims in Ontario employees, 1997. Rates are expressed per 100,000 full-time equivalents (FTEs). One full-time equivalent is 2,000 worked hours (50 wks/year * 40 hrs/wk).

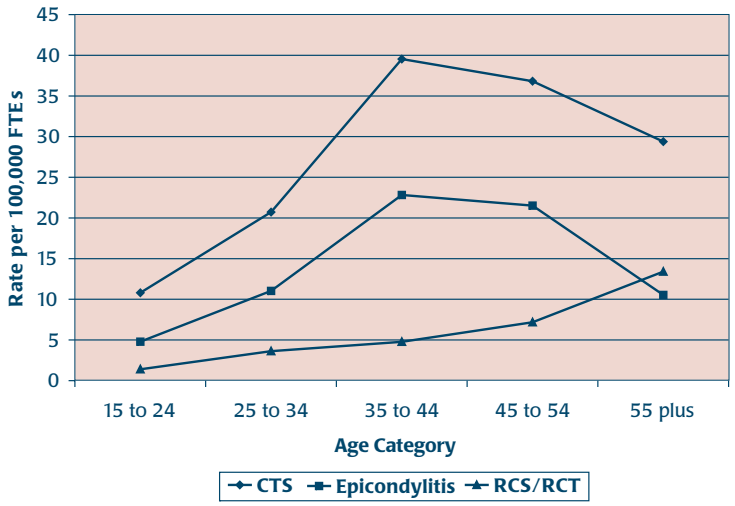
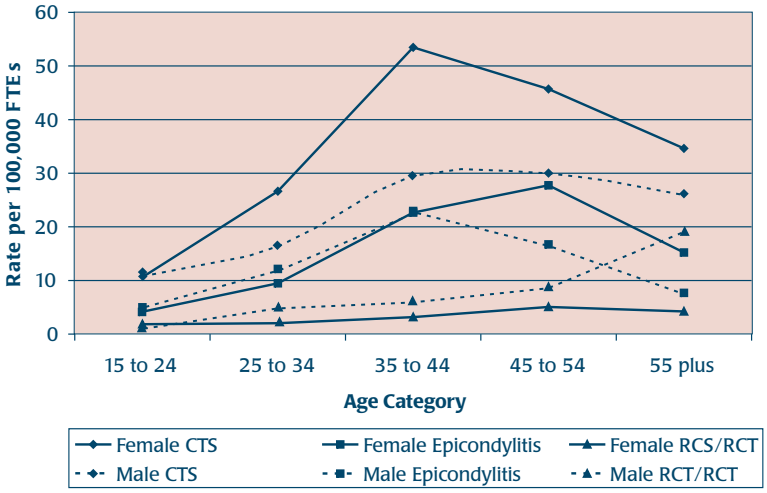


FIGURE 2

Gender and age-specific rates of carpal tunnel syndrome (CTS), epicondylitis, and rotator cuff syndrome/tear (RCS/RCT) claims in Ontario employees, 1997. Rates are expressed per 100,000 full-time equivalents (FTEs). One full-time equivalent is 2,000 worked hours (50 wks/year * 40 hrs/wk).



Frequently occurring highest rate occupations across gender and "nature of injury" included "textiles, furs & leather", "other machining occupations", and "other transportation operators". Frequently occurring highest prevention index occupations across gender and "nature of injury" included "textiles, furs & leather goods", "other machining occupations", and "food, beverage & related processing". In men, "metal products, not elsewhere classified" was consistently identified as having a high prevention index across "nature of injury". Table 5 lists occupations included in these occupational categories. There was greater consistency in the highest rate occupations across gender for a particular "nature of injury" than there was across "nature of injury" for a particular gender. Notwithstanding, the effect of gender was not consistent across "nature of injury" or occupational categories within a particular "nature of injury".

Discussion

Other workers' compensation studies have noted a reduction in the proportion of female claims as one moves proximally along the upper extremity;[4] a higher rate of CTS in women relative to men; [11,23,24] a reduction in the female to male rate-ratio as one moves proximally along the upper extremity;[24] and a parabolic relationship between age and the rate of CTS.[23,24] Potential reasons for gender differences include gender differences in occupational distributions;[16] gender segregation of tasks within the same job title;[25,26] and many biological and social factors not examined by this research.[9] In fact, female CTS rates have been found to be comparable to male rates in occupations which supply similar exposures to both genders.[27] Potential reasons for the parabolic relationship between CTS and epicondylitis claim rates and age include the healthy worker survivor effect;[28–30] workers progressing to physically less stressful jobs as they gain seniority; or policies of the Ontario Workplace Safety & Insurance Board. Specifically, once a claim has been established any recurrences or associated disorders are documented on the initial claim and thus would not be acknowledged in analyses of first-allowed, lost-time claims.[18]

A direct comparison of work-related rates of CTS, epicondylitis, and RCS/RCT claims with previously reported workers' compensation claim rates is difficult because the present research deals with lost-time claims whereas previous work has examined all claims.[1,4,11,23,24,31] However, the Bureau of Labor Statistics' estimate for the incidence rate of occupational CTS involving days away from work was 3.0 per 10,000 FTEs in private industry for 2001 (http://www.bls.gov/iif/home.htm, released Thursday March 27, 2003). This is comparable to the 2.9 per 10,000 FTEs obtained in the present study.

Although the method of categorizing occupations or industries varies across studies, some consistencies were noted regarding high-risk occupations. For example, previous research has identified the following as high risk for CTS: grinding, abrading, buffing and polishing operators; butchers and meat cutters; textile sewing machine operators;[23] shellfish packing; meat/poultry dealers; packing house; fish canneries processing;[11] poultry processing; and meat packing.[31] These appear consistent with the presently identified occupational categories at high risk of CTS: "textiles, furs & leather goods"; "food, beverage & related processing"; and "other machining occupations" (Tables 4 and 5).

CTS and epicondylitis findings were very similar to previously noted definite "wrist & hand" and "elbow & forearm" cumulative trauma disorder findings, respectively.[16] This might be expected as 59% of definite "wrist & hand" cumulative trauma claims had CTS as their "nature of injury", and 69% of definite "elbow & forearm" cumulative trauma claims had epicondylitis as their "nature of injury" (unpublished observations). However, the RCS/RCT claim findings were consistent with the definite + possible "neck & shoulder/shoulder & upper arm" cumulative trauma disorder findings despite the fact that only 3.4 percent of the latter claims had RCS or RCT as their "nature of injury". Additional reasons for consistency across extraction algorithms include "nature of injury" misclassification, or a common etiology for disorders segregated to an anatomical region.

Comparisons of work-related, diagnosis-specific claim rates with general population rates are difficult because of the lost-time nature of the claims and the

TABLE 4

Top five rate and prevention index occupational categories by gender and nature of injury in Ontario employees, 1997

Men	Rate	95% CI	Women	Rate	95% CI
Carpal tunnel syndrome					
Rates					
Fishing, hunting, trapping & related	[a]298.15	–	Mining & quarrying	2146.29	–
Stenographic & typing	284.21	(0.00, 766.62)	Other machining occupations	714.68	(258.67, 1,170.70)
Textiles, furs & leather goods	215.95	(103.87, 328.04)	Mechanics & repairmen	297.75	(33.29, 562.21)
Mining & quarrying	128.65	(51.37, 205.93)	Food, beverage & related processing	254.16	(164.74, 343.58)
Food, beverage & related processing	93.15	(53.55, 132.75)	Other construction	247.28	(0.00, 508.28)
[b]Prevention index					
Metal products, not elsewhere classified	57.16	(41.54, 72.79)	Food, beverage & related processing	254.16	(164.74, 343.58)
Other machining occupations	92.23	(59.52, 124.93)	Textiles, furs & leather goods	202.87	(133.54, 272.21)
Textiles, furs & leather goods	215.95	(103.87, 328.04)	Wood products, rubber, plastics & related & other	171.48	(108.03, 234.93)
Food, beverage & related processing	93.15	(53.55, 132.75)	Other machining occupations	714.68	(258.67, 1,170.70)
Metal shaping & forming	58.42	(34.58, 82.25)	Other service	112.27	(67.03, 157.50)
Epicondylitis					
Rates					
Textiles, furs & leather goods	215.95	(103.87, 328.04)	Other machining occupations	372.88	(93.78, 651.97)
Other machining occupations	67.07	(40.37, 93.77)	Other transportation operators	168.86	(0.00, 455.47)
Other transportation operators	56.31	(11.43, 101.20)	Other processing	144.91	(57.86, 231.95)
Food, beverage & related processing	51.75	(23.67, 79.84)	Textiles, furs & leather goods	128.35	(76.64, 180.06)
Metal products, not elsewhere classified	50.38	(35.82, 64.94)	Wood products, rubber, plastics & related & other	105.52	(58.51, 152.54)
Prevention index					
Other machining occupations	67.07	(40.37, 93.77)	Textiles, furs & leather goods	128.35	(76.64, 180.06)
Metal products, not elsewhere classified	50.38	(35.82, 64.94)	Wood products, rubber, plastics & related & other	105.52	(58.51, 152.54)
Textiles, furs & leather goods	215.95	(103.87, 328.04)	Other machining occupations	372.88	(93.78, 651.97)
Wood products, rubber, plastics & related & other	43.51	(27.37, 59.65)	Other processing	144.91	(57.86, 231.95)
Food, beverage & related processing	51.75	(23.67, 79.84)	Metal products, not elsewhere classified	56.12	(29.18, 83.06)
Rotator cuff syndrome/tear					
Rates					
Fishing, hunting, trapping & related	298.15	–	Other transportation operators	84.43	(0.00, 269.44)
Textiles, furs & leather goods	61.70	(9.10, 114.30)	Other crafts and equipment operators & NEC	20.92	(0.00, 50.56)
Other transportation operators	56.31	(11.43, 101.20)	Other service	18.11	(1.84, 34.37)
Other machining occupations	16.77	(4.69, 28.84)	Textiles, furs & leather goods	16.56	(0.01, 33.11)
Other construction	15.96	(8.21, 23.71)	Nursing, therapy & related	13.94	(6.76, 21.13)
Prevention index					
Other construction	15.96	(8.21, 23.71)	Other service	18.11	(1.84, 34.37)
Other service	14.59	(5.85, 23.33)	Nursing, therapy & related	13.94	(6.76, 21.13)
Other machining occupations	16.77	(4.69, 28.84)	Textiles, furs & leather goods	16.56	(0.01, 33.11)
Other transportation operators	56.31	(11.43, 101.20)	Other crafts and equipment operators & NEC	20.92	(0.00, 50.56)
Metal products, not elsewhere classified	10.66	(4.27, 17.04)	Food, beverage & related processing	11.30	(0.00, 27.11)
Textiles, furs & leather goods	61.70	(9.10, 114.30)			

Note: Only first-allowed, lost-time claims have been considered. Confidence intervals were not calculable when "at-risk" estimates were less than 500 full-time equivalents because approximate coefficients of variation for estimates of annual averages for Ontario, 1997 were not available. NEC = Not Elsewhere Classified.

[a]Rate per 100,000 full-time equivalents (1 full-time equivalent = 50 wks/year * 40 hours/week = 2,000 hours) with 95% CI.

[b]Occupational categories are presented in order of prevention index rank. Since the prevention index is the mean of the frequency of claims rank and rate of claims rank, rates will not necessarily appear in descending order.

TABLE 5
Description of occupational categories

Textiles, furs & leather goods	patternmaking, marking and cutting; tailors and dressmakers; furriers; milliners; shoemaking and repairing; upholsterers; sewing machine operators
Other machining occupations	tool and die making; machinist and machine tool setting-up occupations; machine tool operating occupations; wood patternmaking occupations; wood sawing and related occupations; planing, turning, shaping and related; wood sanding; cutting and shaping clay, glass, stone; abrading and polishing clay, glass, stone; engravers, etchers and related occupations, nec; filing, grinding, buffing, cleaning and polishing, nec; patternmakers and mouldmakers, nec; inspecting, testing, grading, and sampling
Other transportation operators	air pilots, navigators, and flight engineers; air transport operating support; air transport operating occupations, nec; locomotive operating occupations; conductors and brake workers; railway transport operating support; railway transport operating occupations, nec; deck officer; engineering officers, ship; deck crew, ship; engine and boiler-room crew, ship; water transport operating occupations, nec; subway and street railway operating occupations; rail vehicle operators, except rail transport; other transport equipment operating occupations, nec
Food, beverage & related processing	flour and grain milling occupations; baking, confectionery making and related occupations; slaughtering and meat cutting, canning, curing and packing occupations; fish canning, curing and packing occupations; fruit and vegetable canning, preserving and packing occupations; milk processing and related occupations; sugar processing and related occupations; inspecting, testing, grading, and sampling; beverage processing and related occupations
Metal products, nec	engine and related equipment fabricating and assembling occupations, nec; motor vehicle fabricating and assembling occupations, nec; aircraft fabricating and assembling occupations, nec; industrial, farm, construction, and other mechanized equipment and machinery fabricating and assembling occupations, nec; business and commercial machines fabricating and assembling occupations, nec; inspecting, testing, grading and sampling occupations; precision instruments and related equipment

Note: NEC = not elsewhere classified.

sparse general population data. Compared to present CTS findings, general population incidence rates are much greater;[32,33] peak in older age categories;[32–34] and have an older mean age at diagnosis.[33,34] However, an increased risk in women relative to men has been noted in the general population.[32–34] Similarly, RCS/RCT claim findings are inconsistent with general population studies indicating that neck and shoulder disorders are more common among women than men, but are consistent with the increased incidence of neck and shoulder problems with age.[35] These comparisons suggest that work-related diagnosis-specific disorders may have aetiologies that differ from those in the general population.

Limitations

The limitations of this research have been previously detailed[16] and thus will be briefly reviewed. First, the specificity of the occupational categories was limited by the level of detail used in the Labour Force Survey. Consequently, some occupations at high risk of CTS, epicondylitis, or RCS/RCT claims may be masked by the aggregation, but an elevated risk in light of the aggregation is certainly worthy of increased attention. Second, exposure was quantified using broad occupational categories. Hence, this research does not identify the risk factors for CTS, epicondylitis, or RCS/RCT but rather the high-risk occupational categories.

Third, first-allowed, lost-time claims rather than all first-allowed claims were used because only the former were coded in detail. Thus, the rates reflect those injuries significant enough to result in a loss of wages. Therefore, it is possible that occupational categories identified as low risk may have a substantial occurrence of claims that do not result in lost wages. Fourth, as the rates became more and more specific, stability was compromised by a decreasing number of events and smaller population "at-risk" estimates.[36] One solution could be the combining of data from consecutive calendar years. Finally, previous research has demonstrated substantial under-reporting of cumulative trauma disorders of the upper extremity.[37–39] If reported CTS, epicondylitis, and RCS/RCT injuries are not representative of all such injuries, bias may result.

Conclusions

CTS, epicondylitis, and RCS/ RCT claims had differing gender, age and event or exposure distributions. RCS/RCT claimants were primarily male, of older age, and had events or exposures related to overexertion. Gender-specific claim rates and female-to-male rate ratios declined as one moved proximally along the upper extremity. Frequently occurring highest rate and prevention index occupational categories across gender and "nature of injury" included "textiles, furs & leather goods" and "other machining occupations" making both worthy of further investigation. A simple extraction algorithm, which used clinically well defined diagnoses as a surrogate for part of upper extremity-specific cumulative trauma disorders, produced results which were consistent with a previously used, more complex cumulative trauma disorder extraction algorithm.

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We are very pleased to welcome Dr. Claire Infante-Rivard to the position of Associate Scientific Editor of *Chronic Diseases in Canada*.

Dr. Infante-Rivard graduated from the University of Montréal with a medical degree, then completed a master's degree in health administration at the University of California at Berkeley, and a doctorate in epidemiology and statistics at McGill University.

As head of McGill University's Environment and Children's Health Research Group, this doctor and epidemiologist has dedicated her career to prevention and public health and to measuring gene-environment interactions in the development of childhood leukemia.

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