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Carcinogen Surveillance Program

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Carcinogen Surveillance Program

Final Report to the Workers' Compensation Board of British Columbia

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Main Findings

- The 10 most common workplace carcinogens in British Columbia based on the new estimates generated as part of this project are:

Carcinogen	Exposed
Solar radiation	164,875
Diesel engine exhaust (DEE)	107,959
Wood dust	58,074
Polycyclic aromatic hydrocarbons (PAHs excl. ETS & DEE)	46,622
Crystalline silica	44,808
Benzene	40,349
Lead and compounds	20,672
Environmental tobacco smoke (ETS)	17,312
Formaldehyde	10,438
Ionizing radiation	9,958

- It is feasible to estimate the number of people potentially exposed to workplace hazards using existing resources and using CAREX as a starting point is efficient.
- Approaches need to vary by exposure
- Exposure databases such as the WorkSafe BC's former Laboratory Information Management System () are essential, but government reports, research studies, and expert assessment all play a role.

Policy/Prevention Implications

- The data produces by this carcinogen surveillance program can be used to:
    1) Help set priorities for prevention-related activities;
    2) Otherwise aid in developing prevention-related activities;
    3) Monitor trends in exposure to predict future work-related cases;
    4) Assist with claims adjudication; and,
    5) Identify research needs.
- Through use of a combination of existing resources it is possible to derive rough estimates of the numbers of workers potentially exposed to a wide variety of workplace carcinogens. These estimates can be used to assist policy and prevention efforts.

Executive Summary

Research Problem/Context

Many occupational carcinogens are widely recognized because of the efforts of organizations such as the International Agency for Research on Cancer (IARC) and the U.S. National Toxicology Program. However, a lack of data on who is exposed to these carcinogens may hamper efforts to prevent related cancers. By systematically identifying who is exposed to these known carcinogens, we can develop effective strategies to prevent carcinogen-related cancers in workplace and community environments. This process of carcinogen surveillance can be used to set priorities for policy or prevention-related activities, monitor trends in exposure, set research priorities, and share research findings with policy makers and the public.

CAREX, the International Information System on Occupational Exposure to Carcinogens, was developed by the Finnish Institute for Occupational Health (FIOH) as part of a European Union effort to estimate the burden of occupational cancer [Kauppinen et al, 2000]. Its purpose was to produce estimates of the number of people with potential workplace exposure to definite (Category 1), probable (Category 2A), and selected possible (Category 2B) workplace carcinogens, as classified by the International Agency for Research on Cancer in 1995. Initially, CAREX was only used to develop and store exposure estimates for the European Union and the United States. More recently, it has been used to estimate the number of workers exposed to carcinogens in the Baltic countries, the Czech Republic, and Costa Rica, and to aid in estimating the global burden of exposure to occupational carcinogens.

In the late 1990s, we started a pilot project that used the CAREX model to estimate exposure to workplace carcinogens in British Columbia, and were subsequently funded by WorkSafe BC in 2003 to continue the project. Although CAREX was not designed as an ongoing surveillance system, it provides a very useful means for developing provincial estimates of the numbers of exposed workers using local expertise (e.g., knowledge of local industries) and resources (e.g., local labour force data). The objectives of this grant were:

1) To improve on the initial estimates of the number of workers exposed to occupational carcinogens in BC; and

2) To examine the feasibility of other sources of data to improve on the estimates of the number of workers exposed to occupational carcinogens in BC.

Methodology

In the past two years we have adapted the CAREX system for use in Canada and, with the permission of the Finnish Institute for Occupational Health (FIOH), have created CAREX Canada. To do so we:

- modified the programme to focus on occupational carcinogens that are potentially important in Canada and updated and expanded the information on carcinogen classification and OELs
- integrated detailed labour force estimates for British Columbia and Ontario from Statistics Canada into CAREX and modified the programme to allow for more detailed labour force data
- improved the estimates of the number of workers exposed to some of the most common occupational carcinogens in BC using the methods similar to those used by the FIOH to

estimate exposure in Finland, but modifying them to better reflect current Canadian exposure

- obtained databases containing thousands of workplace carcinogen exposure measurements collected by the WorkSafe BC and the Ontario Ministry of Labour and integrated these into CAREX Canada to improve the estimates and provide future users with information regarding exposure levels
- further improved the estimates using information from government reports, research conducted by the University of British Columbia (UBC), the BC Cancer Agency, and other agencies and other published studies

Findings

Initial estimates were generated based on the prevalence of carcinogen exposure in Finland and the United States as part of the original CAREX. Review of the list identified several exposures that were either grossly overestimated or underestimated due to BC or Canadian regulations, geology, or differences. Based on these initial estimates, but taking these differences into consideration, what appeared to be the most common carcinogens in BC were chosen for reassessment. The 10 most common workplace carcinogens in British Columbia identified in this project are solar radiation (164,875 exposed), diesel engine exhaust (107,959 exposed), wood dust (58,074 exposed), polycyclic aromatic hydrocarbons (46,622 exposed, excluding ETS and diesel exhaust), crystalline silica (44,808 exposed), benzene (40,349 exposed), lead and compounds (20,672 exposed), environmental tobacco smoke (ETS)(17,312 exposed), formaldehyde (10,438 exposed), and ionizing radiation (9,958 exposed).

Implications

While our long term goal is to develop a fully functioning occupational carcinogen surveillance program for the province of British Columbia, and eventually all of Canada, the development of such a program will be a multi-stage process. The objectives of this grant were to improve on the initial estimates of the number of workers exposed to occupational carcinogens in BC and examine the feasibility of other sources of data to improve on the estimates of the number of workers exposed to occupational carcinogens in BC.

Estimating the number of people potentially exposed to workplace hazards is feasible using existing resources and using CAREX as a starting point is efficient. Exposure databases (such as the WCB LIMS) are essential, but government reports, research studies, and expert assessment all play a role. As more relevant local data become available, estimates can be continually refined.

The data produces by this carcinogen surveillance program could be sued to help set priorities for prevention-related activities, monitor trends in exposure to predict future work-related cases, assist with claims adjudication, and Identify research needs.

Research Problem/Context

Carcinogen Surveillance and Primary Prevention

Occupational cancer surveillance is useful for identifying previously unrecognized groups at high risk or unexpected sources of exposure to occupational carcinogens [Teschke et al, 1997], but otherwise its usefulness for primary prevention is limited. The period for primary prevention efforts for cancer is 10 to 40 years before diagnosis due to the long induction and latency periods in cancer development. For example, rates of asbestos-related cancers are still increasing over 30 years after substantial efforts were made to reduce and restrict exposure. Many workplace carcinogens have been identified and are widely recognized because of the efforts of organizations such as the International Agency for Research on Cancer (IARC) and the U.S. National Toxicology Program (NTP). Hazard surveillance (systematic efforts to identify who is exposed) has the greatest potential for prevention of disease associated with these recognized carcinogens because it assists prevention activities before excesses of disease have been identified [Fine, 1999; Froines et al, 1989; Griefe et al, 1995].

The only North American surveillance programs designed to identify exposure to a broad range of workplace hazards in the general population have been the 1972-1974 National Occupational Hazard Survey (NOHS) and the 1981-1983 National Occupational Exposure Survey (NOES), both of which were conducted by the U.S. National Institute for Occupational Safety and Health (NIOSH) [Sundin & Frazier, 1989]. Unfortunately, these efforts required a large allocation of resources and were not designed as ongoing programs. The NOES was a survey of 4,490 randomly chosen workplaces to identify all potentially hazardous exposures present. The workplaces were visited by engineering students with limited training in occupational health. Some exposures arising from work processes, such as combustion products and dust or fumes arising from primary materials (e.g. metals or wood), were missed and agriculture and workplaces employing less that 10 workers were not included in the survey.

Despite their limitations, these surveys provided unique data that has been used and cited extensively in prevention, education, and regulation [Boiano & Hull 2001; Sundin & Frazier, 1989]. For several years there has been planning within NIOSH to conduct a new national exposure survey, the National Exposures at Work Survey (NEWS). To our knowledge, this has still not progressed beyond the planning stages because of the large financial costs associated with such an undertaking.

There are some examples of North American, population-based hazard surveillance programs which have focused on a single or a small number of exposures. In Canada, the only ongoing national hazard surveillance program is the National Dose Registry, which monitors workers' exposure to ionizing radiation. Several US states have lead (Pb) surveillance based on mandatory of voluntary reporting of blood lead test results by laboratories [Baser, 1992; Nelson & Kaufman, 1998]. The U.S. Agency for Toxic Substances and Disease Registry has a National Exposure Registry [http://www.atsdr.cdc.gov/NER] of persons exposed to some toxic substances (currently trichloroethylene, trichloroethane, benzene, and dioxin). This approach, which has also been used in Finland, is useful in that it allows for health as well as exposure surveillance. However, it does not include all persons exposed to these substances.

CAREX, the International Information System on Occupational Exposure to Carcinogens, was developed by the Finnish Institute for Occupational Health (FIOH) as part of a European Union effort to estimate the burden of occupational cancer [Kauppinen et al, 2000]. Its purpose was to produce estimates of the number of people with potential workplace exposure to definite (Category 1), probable (Category 2A), and selected possible (Category 2B) workplace carcinogens, as classified by the International Agency for Research on Cancer in 1995. Initially, CAREX was only used to develop and store exposure estimates for the European Union and the United States. More recently, it has been used to estimate the number of workers exposed to carcinogens in the Baltic countries, the Czech Republic, and Costa Rica, and to aid in estimating the global burden of exposure to occupational carcinogens.

Objectives

Although CAREX was not designed as an ongoing surveillance system, it provides a very useful means for developing provincial estimates of the numbers of exposed workers using local expertise (e.g., knowledge of local industries) and resources (e.g., local labour force data). In the late 1990s, we started a pilot project that used the CAREX model to estimate exposure to workplace carcinogens in British Columbia and developed some initial estimates based only on the prevalence of exposure in Finland and the United States. In 2003 we were funded by WorkSafe BC to continue the project. Although our long-term goal is to develop a fully functioning occupational carcinogen surveillance program for the province of British Columbia, and eventually all of Canada, the objectives of this grant were:

1) To improve on the initial estimates of the number of workers exposed to occupational carcinogens in BC; and

2) To examine the feasibility of other sources of data to improve on the estimates of the number of workers exposed to occupational carcinogens in BC.

Methodology

The Creation of CAREX Canada

To assist in generating estimates of the number of workers exposed to carcinogens, CAREX uses a Microsoft© Access relational database program containing detailed labour force data for the European Union and the United States, numbers of people exposed to workplace carcinogens in the same countries, and supplemental exposure information. Prior to starting this project we received permission from Timo Kauppinen of the FIOH to modify CAREX in order to create CAREX Canada.

The original CAREX included all IARC Group 1 (definite) and 2A (probable), and selected 2B (possible) carcinogens, as well as exposure circumstances, as of the mid-1990's when it was created. We limited our work to this group of known and potentially carcinogenic substances. In order to create CAREX Canada, we eliminated agents in the original CAREX that were not useful for occupational surveillance in Canada. CAREX included a number of IARC Category 1 and 2A carcinogens for which there was no, or at least extremely little, potential for workplace exposure. For example, some IARC Group 1 and 2A dietary exposures (e.g. alcoholic beverages, Chinese-style salted fish) and lifestyle exposures (e.g. betel quid with tobacco) were included in the CAREX system for completeness sake, but were eliminated in the current project because there is no potential for occupational exposure. Some infectious agents (e.g. schistosoma haematobium (an African fluke worm)) were also eliminated because there is almost no possibility for workplace exposure in Canada. In the past IARC has classified some exposure circumstances, such as employment in particular industries or occupations, as carcinogenic in order to encourage research to identify the causes for excesses of cancer in those groups. These exposure circumstances have been eliminated because they are of little use for surveillance purposes and, in most cases, the carcinogens have been identified (e.g.

furniture workers). Table 1 provides a list of the agents currently included in CAREX Canada and their IARC classification.

CAREX was designed to estimate the number of people exposed in 55 industry sectors based on the International Standard Industry Codes (ISIC) used by the United Nations. For British Columbia we added detailed labour force estimates from the 2001 Canadian Census. Statistics Canada administers the Canadian Census every five years and approximately 20% of households complete the long questionnaire, which included questions on occupation and industry. This sample is used by Statistics Canada to estimate labour force characteristics for the entire population. The industry information is coded according to the North American Industry Classification System (NAICS, 1997). For CAREX, the NAICS codes were mapped onto the 1968 ISIC-2 categories using the industry description to match as closely as possible the coding system used by CAREX. However, for surveillance purposes a finer level of detail and a breakdown by occupation is preferable. Although providing exposure estimates for hundreds of industrial sectors was beyond the resources of this project, detailed labour force estimates have been added to the program. We have aggregated the 2001 data supplied to us by Statistics Canada to a level useful for carcinogen surveillance.

We also updated the carcinogen information embedded in the program to make it relevant to Canada in 2006. Reference material in the original CAREX program included IARC evaluations and European occupational exposure limits (OELs), as of the mid-1990's when it was created. Since that time there have been a numbers of new IARC evaluations and OELs have also evolved. For example, formaldehyde has been upgraded to Category 1 and lead (Pb) has been upgraded to Category 2A. We have updated the IARC evaluations and added the U.S. NTP evaluations as well. In addition, we have added and/or updated the OELs to include BC WCB, BC Ministry of Mines, and Ontario Ministry of Labour, to represent OELs of local interest. We also included ACGIH, US OSHA, NIOSH, European SCOEL committee, German

MAK Commission, and Swedish OELs because they are the most widely-recognized exposure limits internationally.

In order to make the changes described above, significant modification to the interface and some of the underlying databases were made. Unused elements in the program were eliminated and many screens have been changed to increase readability and add additional information.

Development of British Columbia Estimates

Developing estimates within the CAREX framework was a multi-stage process. Initial estimates were based on the number of workers employed in the industry sectors and the proportion of workers potentially exposed in each sector based on Finnish (FIOH) or U.S. (NIOSH NOES) databases or an average of the two estimates. Prevalence estimates from Finland were primarily based on two sources: the Finnish national register of workers exposed to carcinogens, held by FIOH since 1979, and a comprehensive estimation survey, SUTKEA, conducted by the hygiene staff of FIOH in the late 1980s-early 1990s based on industrial hygiene data collected for research projects or compliance testing. US prevalence estimates were based on the National Occupational Exposure Survey (NOES) carried out by NIOSH from 1981-83 [Sundin & Frazier, 1989]. The NOES used site visits to 4,490 establishments to gather data by occupational category within industry sector. For BC, Finnish, US, or average proportions were chosen for each industry/exposure combination by Dr. George Astrakianakis, a former BC Cancer Agency research associate with experience in assessing exposure in a variety of BC-based industries. Based on the Finnish and U.S. data, we were able to generate initial estimates of the number of workers exposed to the carcinogens included in CAREX.

These estimates provide a good starting point, but are far from accurate for BC and some other provinces in Canada. For example, BC has made significant progress in reducing exposure to environmental tobacco smoke in the workplace and radon, predicted to be a

common exposure in BC (based on FIOH data), is much less common in BC than in Finland because of geologic differences. The first step to improve on the initial estimates was to identify exposures that were grossly underestimated or overestimated. These included estimates where exposures were not comparable between the reference country and BC due to industrial infrastructure, geology, or major regulatory differences. After consideration of these differences, the most common carcinogens were prioritized for further evaluation to improve estimates.

In the next stage, the potentially exposed sub-groups for the most common carcinogens were each reviewed by two or more occupational hygienists (each with training at either the masters or doctorate degree level) to assess whether the conditions identified exist in British Columbia and, where possible, to improve the estimates. As a starting point they examined the logic underlying the Finnish and U.S. estimates to determine if they apply to BC. This was done based on a review of published and grey literature regarding exposure, including studies published by the University of British Columbia or the BC Cancer Agency.

The detailed labour force data was also examined to determine whether BC is comparable. The 55 industry sectors are quite broad and mask differences between BC and the reference countries. For example, the non-ferrous basic metal industry in BC consists primarily of one very large aluminium smelter and one very large lead-zinc smelter, while the Finnish and U.S. estimates are based on a different mix of facilities. As a result, exposures to nickel and arsenic were predicted to be the most common in their estimates and there was a large underestimation of the number of workers exposed to polycyclic aromatic hydrocarbons and lead (Pb) in the initial estimates for that industry sector in BC. By contrast, the wood products industries in BC and Finland are similar in many ways. However, the plywood industry is bigger in Finland. As a result, the preliminary CAREX estimates identified over 4,000 exposed to formaldehyde in that sector, which is likely to be an over-estimate for BC.

Assessment of the Feasibility of Other Sources

To further improve the estimates and to provide additional information on levels of exposure, data was requested from Worksafe BC. Carcinogen exposure measurement data for British Columbia were extracted from the LIMS database. Samples were collected during the time period from 1981 to 2004. For the purposes of this project we focused our efforts on the air sampling data collected for carcinogens. After reconfiguring, cleaning, and applying strict quality assurance criteria, 20,861 valid samples with no missing data were identified for 30 carcinogens. The number of samples stratified by carcinogen, type (area or personal), and 5-year time period are provided in Table 2. The industry information on these samples was recoded to NAICS and the aggregated data was added to the CAREX system for easy retrieval. In addition, 31,493 measurements collected between 1981 and 1996 for nine carcinogens were obtained from the Ontario Ministry of Labour and are summarized in Table 3. These datasets were used to identify exposed sub-groups that were not previously identified by CAREX.

A wide variety of government reports were consulted to update estimates for specific carcinogens. For example, reports from the National Dose Registry, a federal-provincial programme to collect and publish data on radiation exposure, were used to update estimates for exposure to ionizing radiation. A survey of pesticide use in British Columbia was used to identify exposure to carcinogens used as wood preservatives, antisapstain agents, and for ornamental and agricultural products. Regulations, such as BC regulations regarding environmental tobacco smoke, Canadian Environmental Protection Act (CEPA) lists of prohibited toxic substances and Health Canada lists of banned drugs, were also consulted. Targeted and broad internet searches were also conducted to identify other useful resources, such as the Canadian Chemical Producers' Association overview of the chemical industry in Canada.

Data collected as part of studies conducted by researchers from the University of British Columbia and the BC Cancer Agency was also used. These include large cohort studies, large

exposure assessment studies, and smaller research projects performed by students and faculty. For example, the BC Sawmill Workers Study was used to estimate the prevalence of exposure to wood dust [Friesen et al, 2005], the Alcan aluminum smelter study was used for exposure to polycyclic aromatic hydrocarbons [Friesen et al, 2006], the BC nurses study was used to assess exposure to ionizing radiation and anti-neoplastic agents [Chung et al, 2005; Ward et al, 2005], and the Teck-Cominco cohort study feasibility report was used to assess exposure to lead and cadmium [Spinelli et al, 2004].

Findings

The initial estimates of the most common workplace carcinogens in BC are provided in Table 4. Preliminary review of the list identified several exposures that were either grossly overestimated or underestimated. For example, the proportion of people exposed to environmental tobacco smoke in the workplace is much lower now than it was historically, radon exposure is much more common in Finland than in BC due to differences in geology, and ethylene dibromide has been banned in Canada for use as a pesticide and is no longer used as a common fuel additive. On the other hand, exposure to diesel engine exhaust and other polycyclic aromatic hydrocarbons appear to be more common than indicated and the National Dose Registry indicated that more people might be exposed to radiation in the workplace.

Based on this initial assessment, what appeared to be the most common carcinogens were chosen for re-assessment. Table 5 displays the top 10 carcinogens based on the improved estimates. Solar radiation remains in the top position, although the numbers have changed substantially because the Finns used a survey to identify the proportion within industries while we classified specific jobs within each industry as involving indoor, outdoor, or mixed activities. Exposure to diesel engine exhaust and polycyclic aromatic hydrocarbons were increased primarily because of a more sensitive approach to exposure to vehicle exhausts. On

first glance the number exposed to wood dust and crystalline silica changed little. However, there were somewhat fewer classified as exposed within the industries previously classified as exposed and more classified as exposed in other industries.

In order to display the features of CAREX Canada and its utility, exposure to crystalline silica will be used as an extended example. As mentioned earlier, data from CAREX Canada are stored in a Microsoft Access Database where they can be easily searched. Figure 1 is the opening screen. Figures 2 through 6 present an example focusing on exposure to crystalline silica and the non-metallic minerals products manufacturing sector. Figure 2 displays our primary search screen. It can be seen that based on our estimates there would be 1173 people exposed in BC in the selected sector, while Finnish or American data would have produced estimates of 2142 and 610 exposed, respectively. Appendix A provides an example of the reports that can be generated by CAREX. It provides a listing of the industry sectors where exposure to silica may occur. A total of 44 (out of a total of 55) sectors were identified. This list of industries includes many not identified in the initial estimates. The exposure measurement data from the LIMS database provided by Worksafe BC was used to identify industries in which exposures have been measured but that had not been considered in the original CAREX. In the case of silica, these included logging, wood products, food, beverage, and chemical industries and several other industries. In most cases these represented small numbers of workers. However, they were not necessarily lightly exposed.

The “Definition of Carcinogen” button (Figure 2, left hand side of screen) leads to another screen that provides the criteria used to define who is exposed and includes information on BC, Ontario, US, and European regulatory limits (Figure 3). Exposure estimates are based on the identification of exposed subgroups using detailed labour force data (Figure 4). Currently, CAREX Canada uses the industry sectors developed for the original CAREX based on broad ISIC industry codes (Figure 5). However, the underlying data used in CAREX Canada is based on the NAICS industry codes to match those used by Statistics Canada (Figure 6).

Implications

The purpose of this grant was to assess the usefulness of CAREX as a tool to estimate the number of BC workers exposed to carcinogens and to identify methods to develop improved estimates. Through use of a combination of existing resources it is feasible to estimate the number of workers potentially exposed to a wide variety of workplace carcinogens. Approaches need to vary by exposure, but initial estimates from CAREX were a useful starting place. Expert assessment played a key role in improving the estimates. However, exposure databases were essential, and data from government reports, research studies, and the grey literature can all play a role.

One of the limitations of using CAREX as a surveillance tool is that exposure is defined very broadly. It is important to recognize that the underlying objective of CAREX is to measure hazard rather than risk. Thus, it is designed to estimate the number potentially exposed above a defined background level rather than the number exposed at a level associated with a measurably increased risk of cancer. The criteria for exposure to each agent are defined specifically to include all exposures above background levels. In many industries the majority of workers are, hopefully, exposed to relatively low levels in terms of health effects. For example, in a recent study of aluminium smelter workers, over 50% were exposed to coal tar pitch volatiles, but the great majority at levels below half the current recommended standards [Friesen et al, 2006]. Similarly, the great majority of workers employed in BC sawmills have some exposure to wood dust, but most at very low levels [Hall et al, 2002]. However, for prevention purposes it would also be useful to know how many workers are exposed to high levels.

The numbers of people identified as potentially exposed by CAREX are best described as robust estimates. In order to determine the precise numbers, two different approaches are conceivable: require all employers to report the number of workers potentially exposed or

develop a system to conduct periodic workplace inspections of all, or at least a sizable sample of employers, as was done with the U.S. National Occupational Exposure Survey. The latter would perhaps be the more reliable approach, but the resources for either would be considerable. However, knowing where people are exposed and having a rough idea of numbers may be adequate for prevention activities in many situations. Equally important is having the ability to identify the most highly exposed workers. Adding more data on levels of exposure is a key goal for future improvements to this project.

We currently have a proposal under consideration for funding by the Canadian Partnership Against Cancer Corporation (CPACC, formerly the Canadian Strategy for Cancer Control) to create a National Environmental and Occupational Carcinogen Surveillance Unit. It would be based at the UBC School of Occupational and Environmental Hygiene and also associated with the Population Health Learning Observatory (PHLO). The proposal includes the creation of a National Workplace Exposure Database. We will be contacting agencies across Canada responsible for collecting workplace exposure data to request their data in either a raw or aggregate form. This will substantially enhance the amount of exposure data available within CAREX Canada.

In the interim, the CAREX project is being supported as part of the Worksafe BC-Centre for Health Services and Policy Research Partnership. In addition, PHLO is supporting efforts to continue work on the LIMS database (completing the work started under the current project). We are also approaching the BC Ministry of Mines as well as Human Resources and Skills Development Canada and the National Dose Registry regarding their BC data.

Policy and Prevention

The data provided by CAREX will primarily be of use to agencies such as Worksafe BC and other organizations entrusted with the protection of worker health. When fully developed, data from CAREX Canada could be used to set priorities for prevention-related activities and identify groups in need of further investigation. In the context of workers' compensation, it could be used to assist with claims adjudication and help predict the future burden of cancer. It could also be used to identify research needs. Lastly, it could be used to educate policy makers and the public regarding the human and financial costs of workplace cancer and the necessity to initiate prevention activities.

As an example, recent studies indicate that occupational exposure limits for crystalline silica (IARC Category 1) may have been too high to prevent excess cases of silicosis or lung cancer. This has resulted in the lowering of occupational exposure limits in some jurisdictions. CAREX can identify the industries in which exposure may occur and estimate the number exposed within those industries. This could assist WorkSafe BC to target efforts to notify employers and worker representatives of impending changes in regulations or other policies or to assess the financial or administrative impact of lowering exposure limits. In addition, easy access to data on levels of exposure could assist in targeting sectors for educational or compliance activities. For the purposes of compensation, a claims adjudicator would be able to easily access available data on exposure for a claimant. From a planning perspective, it could also be used as an actuarial tool. For example, data on the number of workers exposed and approximate levels of exposure could be used to help predict the number of future cancer and silicosis claims and the industries in which they may arise.

It is important to stress that the utility of CAREX goes beyond cancer. For example, it includes many common respiratory hazards (e.g. wood dust, silica, asbestos, and TDI), toxic metals (lead, arsenic, and chromium) and common chlorinated solvents (perchloroethylene, trichloroethylene, and methylene chloride). Thus, in a broader application, data from CAREX

could be used to assist in setting priorities. For example, in the past we have been approached by WorkSafe BC to provide information to assist with setting priorities for what substances should be considered for periodic review of occupational exposure limits and we have received similar requests from the National WHMIS Office. The lack of reliable estimates of the number of workers exposed limited our ability to respond to these requests will help us respond more effectively in the future.

Dissemination/Knowledge Transfer

As mentioned earlier, CAREX will primarily be of use to organizations entrusted with the protection of occupational health, such as Worksafe BC. With the submission of this written report, we will be submitting an electronic version of CAREX Canada to Worksafe. Although it is relatively simple to use, it should still be considered a "Beta" version and instructions in its use and the interpretation of its output are necessary. We would like to conduct a workshop to provide key potential users with the background necessary to use it and provide a live demonstration of its use. We will also be supplying copies to organizations, such as Workplace Hazardous Materials Information System (WHMIS), which have expressed interest in the project.

CAREX may also be of interest to a wider community of individuals and organizations. These may include industry and labour organizations interested in how their workplaces are portrayed and people involved with advocacy groups and politicians engaged in the public debate regarding exposure to carcinogens and their regulation. The principal tool for the wider dissemination of the results of this project will be the Internet. In March, 2007 we will launch a new web site (http://www.cher.ubc.ca/CAREX/), hosted on the UBC Centre for Health and Environment site, to make the results of this project publicly available. The web site will be patterned loosely after the main CAREX web site created by the Finnish Institute for

Occupational Health (http://www.ttl.fi/Internet/English/Organization/Collaboration/Carex/) and will present background material on the CAREX project as well as a number of downloadable reports in PDF Format including:

a) The current report

b) Agents Currently Included in CAREX Canada

c) Detailed Carcinogen Information (as in figure 3)

d) The Top Occupational Carcinogens in BC

The web site will also invite comments and questions to be submitted by e-mail, mail, or phone. Comments regarding the accuracy, readability, and usability of the data and text in the web site will be specifically requested and suggestions will be incorporated whenever feasible.

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Nhu Le, of the BC Cancer Agency, and Kay Teschke, from UBC contributed to the development of this project. We would also like to than Loraine Marrett and Bronwen Waller, from Cancer Care Ontario, for their collaboration and assistance. Yat Chow, Megan Winter, and Andrea Lam also contributed to developing the estimates of the numbers of people exposed to specific substances.

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Table 1: Agents Included in CAREX Canada

Occupational Agent [CAS#]	IARC Group
4-Aminobiphenyl [92-67-1]	1
Acrylamide [79-06-1]	2A
Adriamycin [23214-92-8]*	2A
Acrylonitrile [107-13-1]	2B
Aflatoxins [1402-68-2]	1
Androgenic steroids [many]*	2A
Arsenic and its compounds [7440-38-2]	1
Asbestos [1332-21-4]	1
Azacitidine [320-67-2]*	2A
Azathioprine [446-86-6]*	1
Bischloroethyl nitrosourea (BCNU) [154-93-8]*	2A
Bis(chloromethyl)ether & chloromethyl methyl ether [542-88-1]	1
Benzidine-based dyes [many]	2A
Beryllium and its compounds [7440-41-7]	1
Benzene [71-43-2]	1
Benzidine [92-87-5]	1
1,3-Butadiene [106-99-0]	2A
1,4-Butanediol dimethanesulfonate (Myleran) [55-98-1]*	1
Cadmium and its compounds [7440-43-9]	1
Captafol [2425-06-1]	2A
Carbon tetrachloride [56-23-5]	2B
Ceramic fibers [n/a]	2B
Chlorambucil [305-03-3]*	1
Chloramphenicol [56-75-7]*	2A
Chlorozotocin [54749-90-5]*	2A
Chromium VI compounds [many]	1
Ciclosporin [79217-60-0]*	1
Cisplatin [15663-27-1]*	2A
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea [13909-09-6]*	1
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) [13010-47-4]*	2A
Cobalt and its compounds [many]	2B
Cyclophosphamide [50-18-0]*	1
Creosotes [8001-58-9]	2A
Coal-tars [8007-45-2]	1
Diesel engine exhaust [mixture]	2A
Diethylstilboestrol [56-53-1]	1
Diethyl sulfate [64-67-5]	2A
Dimethylcarbamoyl chloride [79-44-7]	2A
Dimethyl sulfate [77-78-1]	2A
Epichlorohydrin [106-89-81]	2A
Erionite [66733-21-9]	1
Ethylene dibromide [106-93-4]	2A
Ethylene oxide [75-21-8]	1
Environmental tobacco smoke (at work) [mixture]	1
Formaldehyde [50-00-0]	1
Glasswool [n/a]	2B
Helicobacter pylori [n/a]	1
Hepatitis B virus [n/a]	1
Hepatitis C virus [n/a]	1
Ionizing radiation and radioactive elements (exclu. radon) [n/a] (X & gamma radiation, neutrons, phosphorus-32, plutonium radioiodines, radionuclides, radium (224, 226, 228))	1
Lead and lead compounds [7439-92-1]	2A
Melphalan [148-82-3]*	1
5-Methoxypsoralen [484-20-8]*	2A
8-Methoxypsoralen therapy [298-81-7]*	1
Methylene chloride [75-09-2]	2B
4,4'-Methylene bis(2-chloroaniline) (MOCA) [101-14-4]	2A

Table 1 (continued): Agents Included in CAREX Canada

Occupational Agent [CAS #]	IARC Group
Mustard gas (sulphur mustard) [505-60-2]*	1
Mineral oils, untreated [mixture]	1
MOPP and other chemotherapy, including alkylating agents [many]*	1
N-Ethyl-N-nitrosourea [759-73-9]	2A
N-Methyl-N'-nitro-N-nitrosoguanidine (MNNG) [70-25-7]*	2A
N-Methyl-N-nitrosourea [684-93-5]	2A
N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine) [494-03-1]*	1
N-Nitrosodiethylamine [55-18-5]	2A
N-Nitrosodimethylamine [62-75-9]	2A
2-Naphthylamine [91-59-8]	1
Nickel compounds [many]	1
Nitrogen mustard [51-75-2]*	1
Non-arsenical insecticides [many]	2A
Oestrogens, nonsteroidal [many]*	1
Oestrogens, steroidal [many]*	1
Oral contraceptives, combined [many]*	1
Oral contraceptives, sequential [amny]*	1
para-Chloro-ortho-toluidine & its strong acid salts [95-69-2]	2A
Pentachlorophenol [87-86-5]	2B
Polychlorinated biphenyls (PCBs) [1336-36-3]	2A
Polycyclic aromatic hydrocarbons (PAHs) [mixture]	2A
Procarbazine hydrochloride [366-70-1]*	2A
Radon and its decay products [10043-92-2]	1
Shale-oils [68308-34-9]	1
Silica, crystalline [14808-60-7]	1
Solar radiation [n/a]	1
Styrene [100-42-5]	2B
Styrene-7,8-oxide [96-09-3]	2A
Sulfuric acid mist [7664-93-9]	1
Talc containing asbestiform fibres [mixture]	1
Tetrachloroethylene [127-18-4]	2A
Thiotepa [52-24-4]*	1
Tresulfan [299-75-2]*	1
Tris(2,3-dibromopropyl)phosphate [126-72-7]	2A
1,2,3-Trichloropropane [96-18-4]	2A
Trichloroethylene [79-01-6]	2A
Ultraviolet (UV) radiation, artificial [n/a]	2A
Vinyl bromide [593-60-2]	2A
Vinyl chloride [75-01-4]	1
Vinyl fluoride [75-02-5]	2A
Wood dust [n/a]	1

* Pharmaceuticals agents to which health care and pharmacy industry workers may be exposed, many are now banned from use in Canada.

Table 2: Carcinogen Exposure Measurements Collected by Worksafe BC and Included in CAREX by Carcinogen, Type (area or personal), and Time Period

	1980-1984		1985-1989		1990-1994		1995-1999		2000-2004		Total	
Carcinogen	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**
ACID	8	3	10	4	14	6	70	23	62	4	164	40
Arsenic	26	12	2	0	0	9	0	0	0	0	28	21
Asbestos	791	104	634	157	237	151	86	1	10	4	1,758	417
BAA	2	36	0	35	10	7	34	24	22	70	68	172
BAP	2	36	28	41	11	7	36	25	22	70	99	179
Beryllium	6	7	2	8	0	7	4	1	9	7	21	30
Benzene	46	19	15	11	6	8	12	27	5	12	84	77
Carbon tetrachloride	0	0	0	0	0	0	0	0	0	8	0	8
Cadmium	22	74	70	208	10	65	44	76	40	40	186	463
Cobalt	7	30	37	104	46	331	102	216	52	41	244	722
Chromium	26	41	30	31	12	17	4	19	0	0	72	108
Coal Tar	1	6	15	37	1	8	6	21	11	21	34	93
Ethylene Oxide	13	4	27	4	3	1	0	0	0	0	43	9
Env. Tobacco	0	0	46	1	5	1	0	0	10	0	61	2
Formaldehyde	543	83	390	27	107	35	279	208	230	51	1,549	404
Glasswool	0	0	2	3	1	1	7	9	6	2	16	15
Methylene Chloride	31	127	74	217	12	170	31	73	3	0	151	587
MOCA	2	0	1	0	4	4	4	6	0	0	11	10
Mineral Oil	58	4	74	34	118	13	16	7	0	0	266	58
Nickel	48	136	85	220	46	216	94	170	101	137	374	879
PAH	17	237	40	205	75	61	211	157	122	390	465	1,050
Lead	81	209	99	239	66	172	101	164	61	63	408	847
PCB	2	0	10	0	3	0	15	0	0	0	30	0
Pentachlorophenol	42	27	43	36	0	0	0	0	4	2	89	65
Percholoroethylene	36	59	135	81	89	185	120	1,042	0	0	380	1,367
Crystalline Silica	34	133	69	324	26	61	69	145	28	35	226	698
Styrene	21	57	103	296	38	349	45	80	9	27	216	809
Trichloroethylene	41	24	23	6	8	25	6	16	0	0	78	71
Vinyl Chloride Mono.	8	6	29	18	9	3	4	12	0	8	50	47
Wood dust	540	709	390	803	153	699	318	508	148	174	1,549	2,893
Total	2,454	2,183	2,483	3,150	1,110	2,612	1,718	3,030	960	1,166	8,720	12,141

Table 3: Carcinogen Exposure Measurement Samples Collected by Ontario Ministry of Labour Included in CAREX by Carcinogen, Type (area or personal) & Time Period

	1981-1984		1985-1989		1990-1996		Total	
Carcinogen	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**	**Area**	**Pers**
Asbestos	193	334	91	85	39	15	323	434
Benzene	39	33	516	321	230	165	785	519
Cadmium	82	109	260	370	35	68	377	547
Ethylene dibromide	6	4	0	0	0	0	6	4
Formaldehyde	1,000	99	4,260	437	1,499	312	6,759	848
Lead	325	374	1,920	2,895	883	1,291	3,128	4,560
Perchloroethylene	68	39	837	653	543	526	1,448	1,218
Crystalline Silica	224	252	1,098	1,636	463	919	1,785	2,807
Styrene	242	274	1,601	2,375	526	927	2,369	3,576
Total	2,179	1,518	10,583	8,772	4,218	4,223	16,980	14,513

Table 4: Most Common Carcinogens in British Columbia: Initial Estimates based on Finnish and U.S. Prevalence

Carcinogen	Estimate
Solar radiation	123,626
Environmental tobacco smoke	104,715
Wood dust	62,976
Crystalline silica	44,552
Radon and decay products	44,039
Diesel engine exhaust	40,390
Benzene	24,539
Ethylene dibromide	23,689
Lead and compounds	14,550
Glasswool	8,717
Asbestos	8,140
Tetrachloroethylene	7,711
Formaldehyde	7,010
Chromium VI and compounds	6,651
Polycyclic Aromatic Hydrocarbons (excl. environmental tobacco smoke & diesel engine exhaust)	6,571
Nickel compounds	4,255
Ionizing radiation	3,192
Arsenic and compounds	3,061
Styrene	1,903
Cadmium and compounds	1,859
Strong acid mists	1,519
Cobalt and compounds	1,816
Strong-inorganic-acid mists containing sulfuric acid	1,519
Pentachlorophenol	849

Table 5: Top 10 Occupational Carcinogens in BC based on Improved Estimates

	Initial Estimate		Improved Estimate*	
Rank	**Carcinogen**	**Count**	**Carcinogen**	**Count**
1	Solar radiation	123,626	Solar radiation	164,875
2	Environmental tobacco smoke	104,715	Diesel engine exhaust (DEE)	107,959
3	Wood dust	62,976	Wood dust	58,074
4	Crystalline silica	44,552	PAHs (excl. ETS & DEE)	46,622
5	Radon	44,039	Crystalline silica	44,808
6	Diesel engine exhaust	40,390	Benzene	40,349
7	Benzene	24,539	Lead and compounds	20,672
8	Ethylene dibromide	23,689	Environmental tobacco smoke (ETS)	17,312
9	Lead and compounds	14,550	Formaldehyde	10,438
10	Glasswool	8,717	Ionizing radiation	9,958

* Improved estimates were not generated for Radon.

Figure 1: CAREX Canada Opening Interface

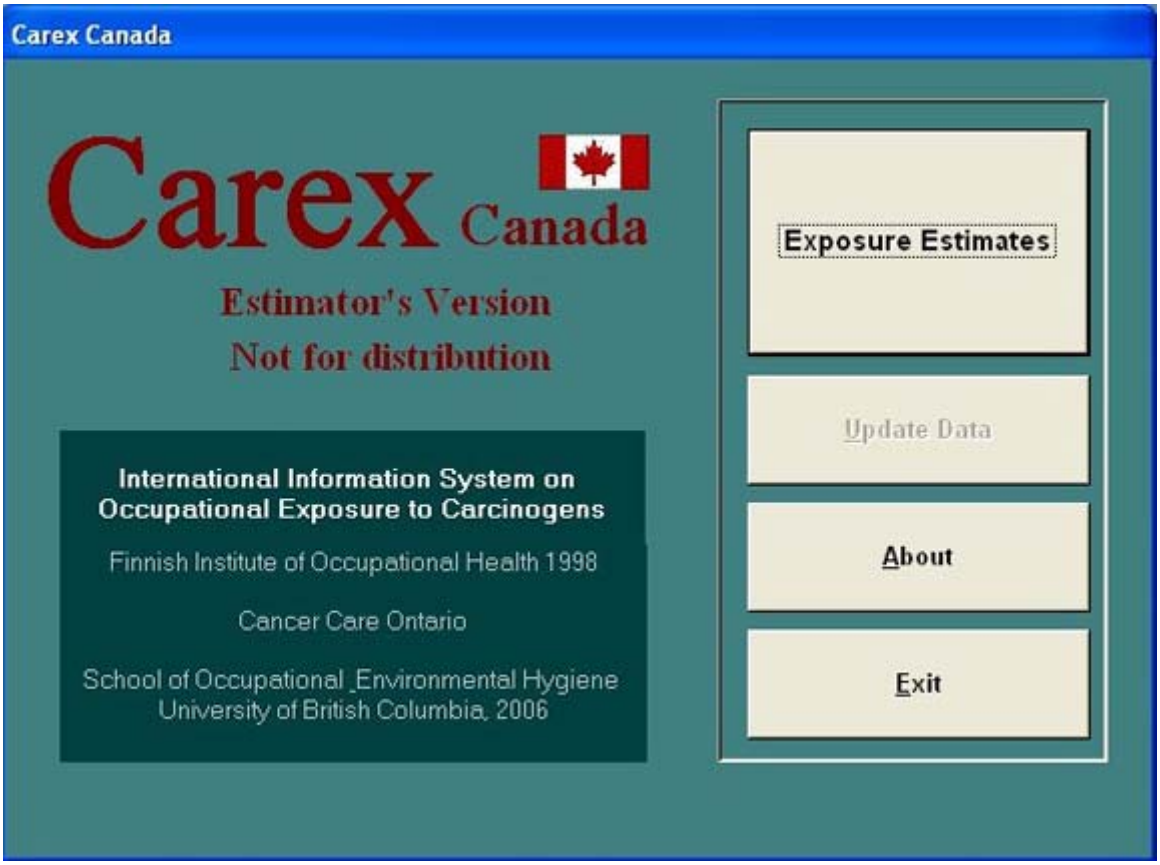


Figure 2: CAREX Canada Primary Exposure Estimation Screen

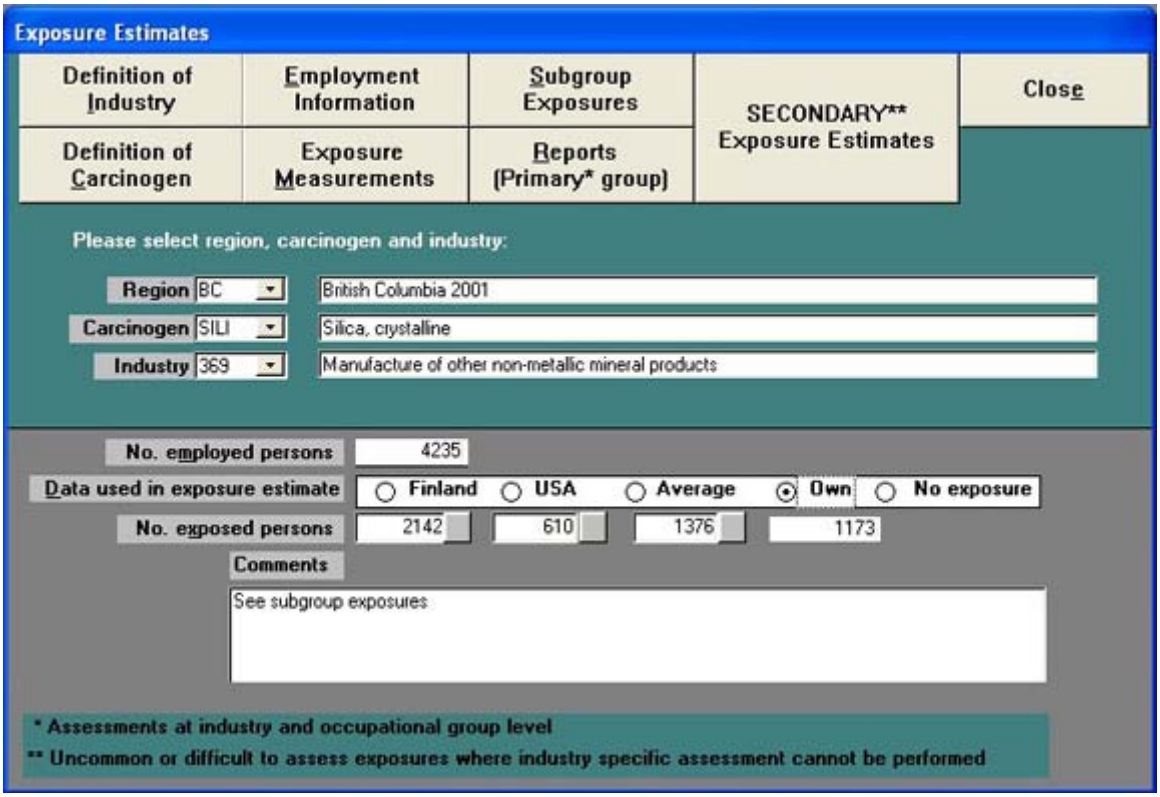


Figure 3: CAREX Canada Carcinogen Information

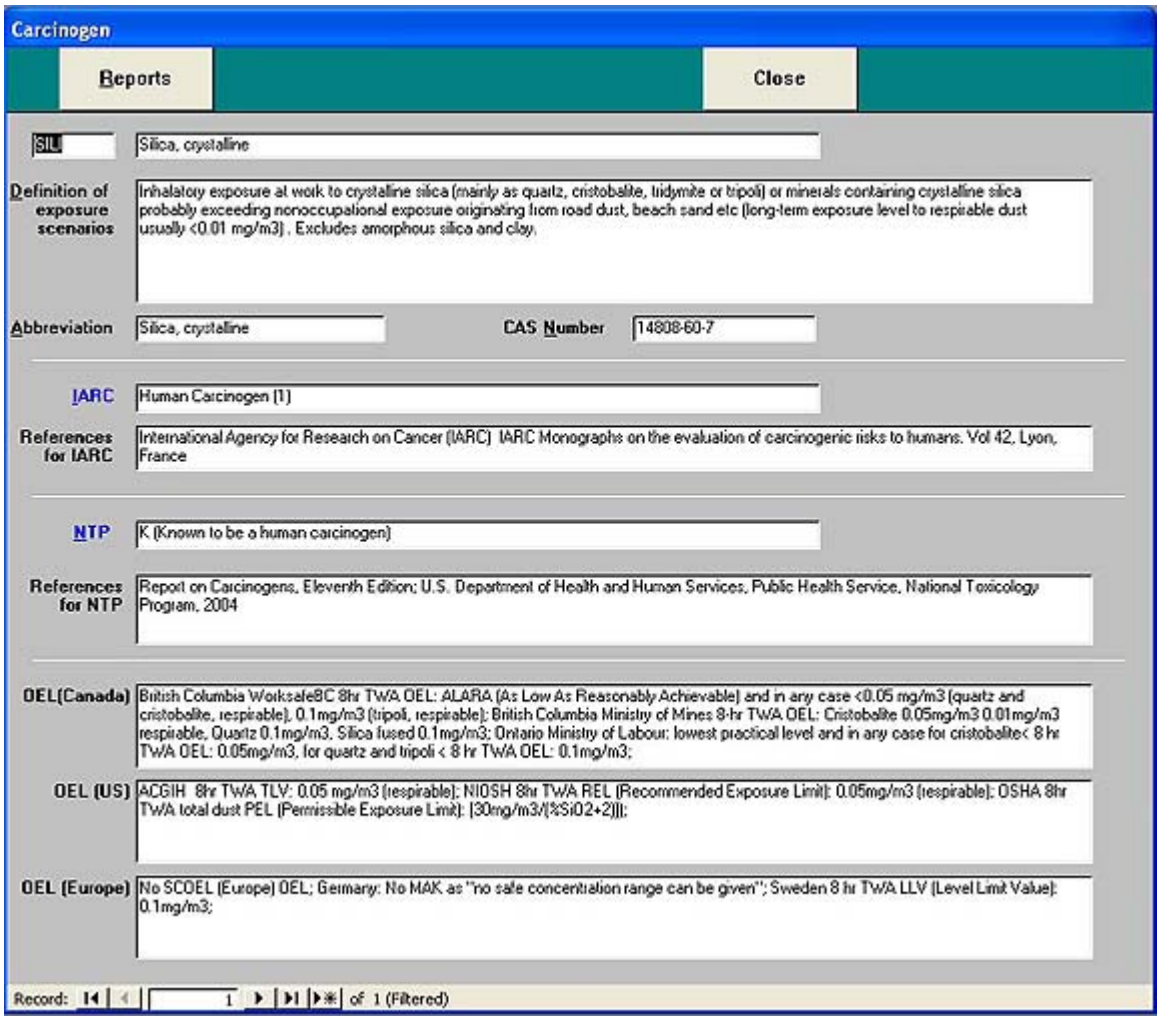


Figure 4: CAREX Canada Subgroup Exposure Information

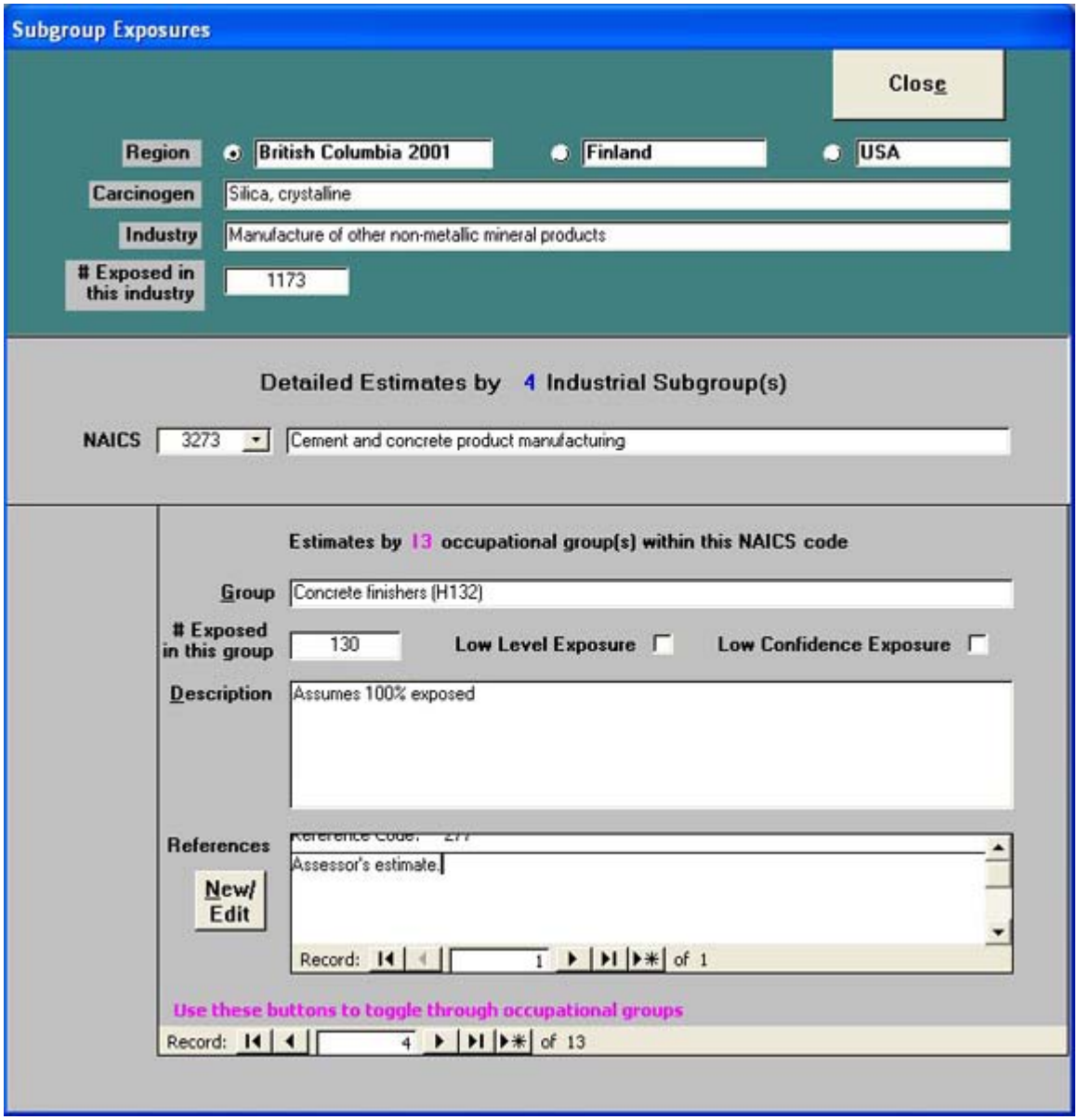


Figure 5: CAREX Canada Industry Information

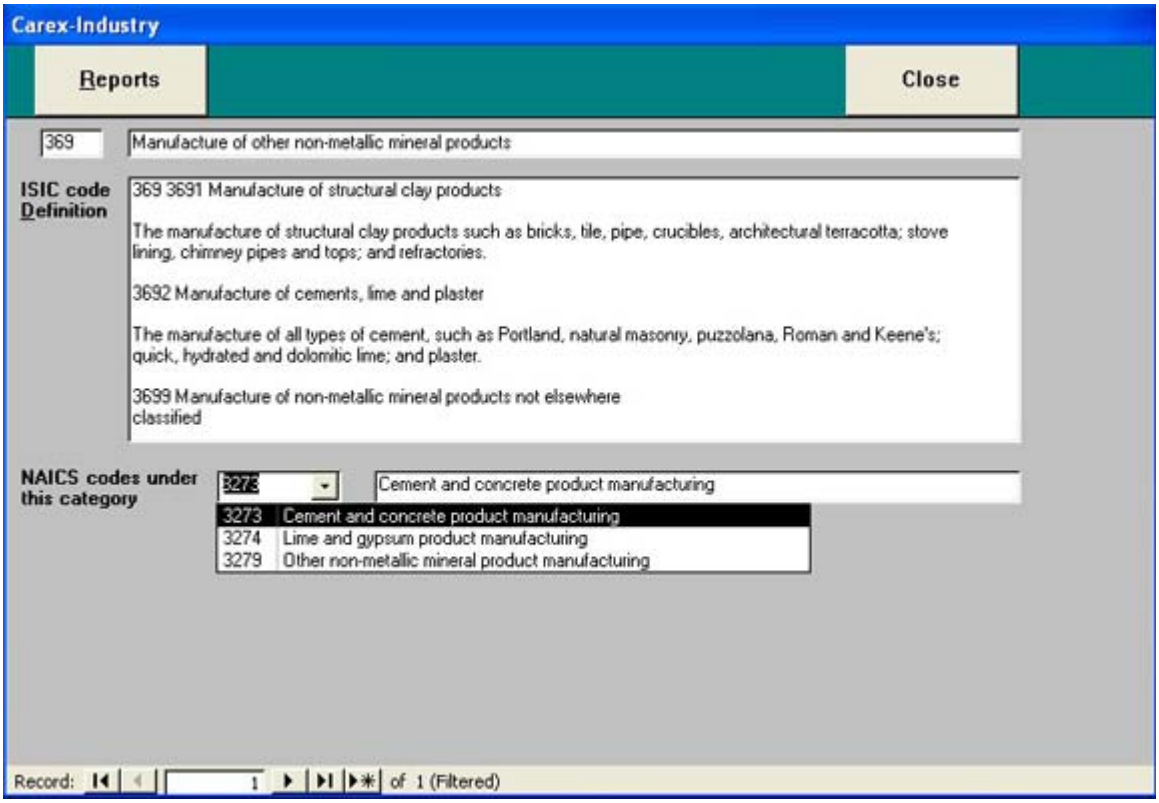
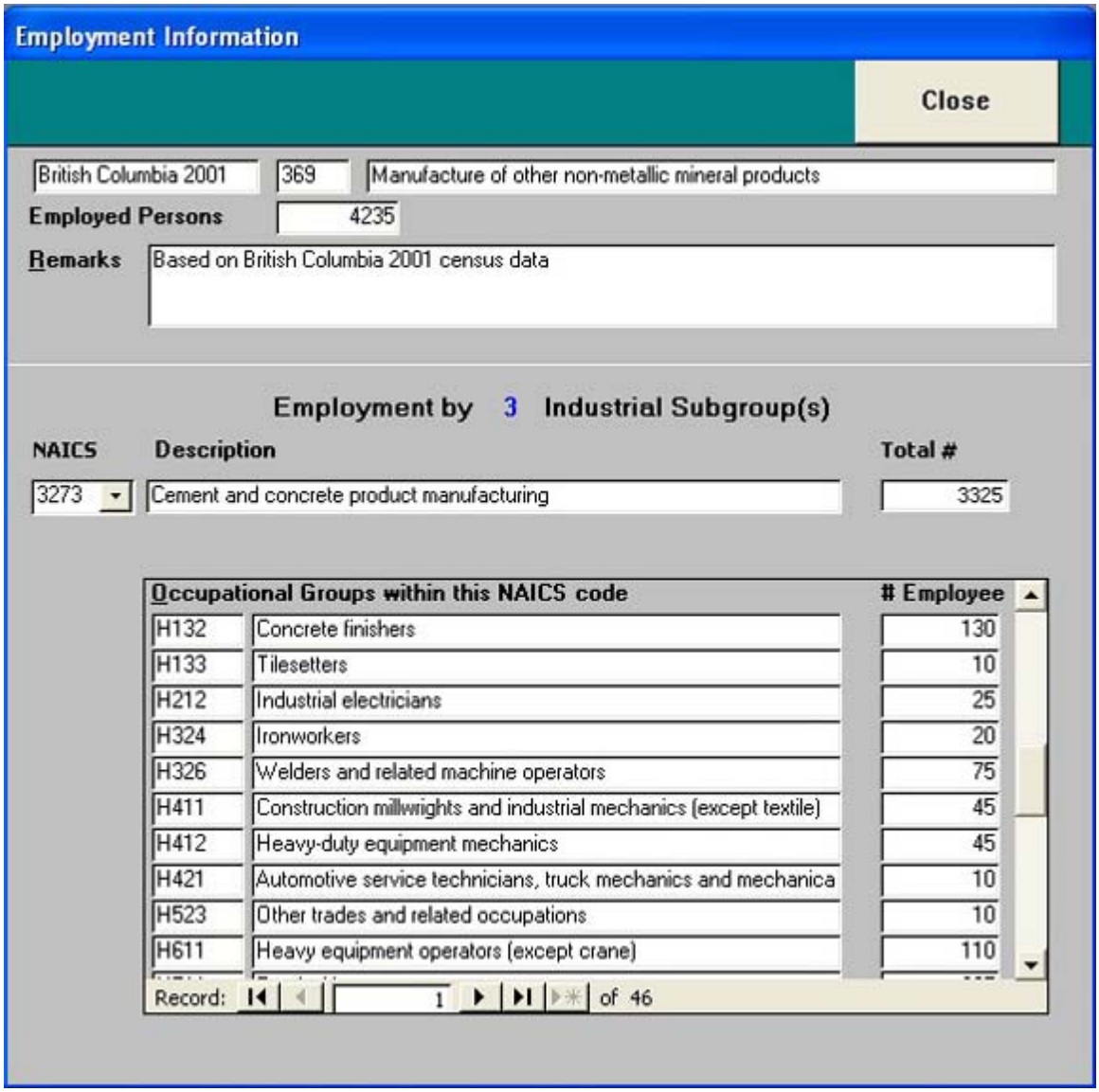


Figure 6: CAREX Canada Labour Force Information



Appendix A: Carex Industry Specific Estimates - Summary

British Columbia 2001: Silica, crystalline

ISIC	Industry	Estimate
11	Agriculture and hunting	13
12	Forestry and logging	164
21	Coal mining	246
22	Crude petroleum and natural gas production	19
23	Metal ore mining	1596
29	Other mining	495
311-2	Food manufacturing	6
321	Manufacture of textiles	1
322	Manufacture of wearing apparel, except footwear	10
331	Manufacture of wood and wood and cork products, except	190
332	Manufacture of furniture and fixtures, except primary of	45
341	Manufacture of paper and paper products	30
342	Printing, publishing and allied industries	10
352	Manufacture of other chemical products	258
354	Manufacture of miscellaneous products of petroleum and	13
356	Manufacture of plastic products not elsewhere classified	235
361	Manufacture of pottery, china and earthenware	560
362	Manufacture of glass and glass products	529
369	Manufacture of other non-metallic mineral products	1173
371	Iron and steel basic industries	334
372	Non-ferrous metal basic industries	487
381	Manufacture of fabricated metal products, except	195
382	Manufacture of machinery except electrical	264
383	Manufacture of electrical machinery, apparatus, appliances	5
384	Manufacture of transport equipment	33
385	Manufacture of instruments, photographic and optical	11
39	Other manufacturing industries	81
41	Electricity, gas and steam	45
42	Water works and supply	238
5	Construction	33004
6	Wholesale and retail trade and restaurants and hotels	913
711	Land transport	1868
712	Water transport	56
713	Air transport	53
719	Services allied to transport	16
8	Financing, insurance, real estate and business services	567
91	Public Administration and Defense	669
92	Sanitary and similar services	138
931	Education services	50
933	Medical, dental, other health and veterinary services	20
934	Welfare institutions	5
935-9	Business, professional and other organisation	5
94	Recreational and cultural services	50
95	Personal and household services	108
	Total	44808

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