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Capacity Development for a Canadian Workplace Exposure Database

July 2014

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Report to the WorkSafeBC Research Services
FOCUS ON TOMORROW "RESEARCH AT WORK" program

Capacity Development for a Canadian Workplace Exposure Database

(RS-2010_OG13)

July 2014

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MAIN RESEARCH FINDINGS

- Occupational exposure databases play an important role in both occupational health research and policy development. Large databases are most helpful in population level epidemiology.
- Canada does not currently have a coordinated (national) occupational exposure database; Canadian occupational exposure holdings are widespread and often difficult to access because that data is only available on paper records.
- The objective of this project was to help build the Canadian Workplace Exposure Database (CWED) by enabling the capture and addition of exposure data from BC Ministry of Energy and Mines and the Government of Saskatchewan.
- We abstracted 31,764 individual exposure measurements from the two data streams (22, 575 from BC Mines), covering a period of 1975 to 2011. Six percent were “non-detects”.
- We abstracted complete data on chemical identity, concentration measure units of measurement, date of sampling and Industry. Other data suffered from some degree of missing values.
- Data for 58 and 190 substances were abstracted from BC Mines and Saskatchewan sources, respectively. Saskatchewan data was from 19 different industry sectors.
- The BC Mines and Saskatchewan exposure data add 7.5% more data to the Canadian Workplace Exposure Database, joining data from BC (Worksafe), Ontario, Manitoba, Yukon and Quebec. CWED is currently working with Alberta, Newfoundland and Labrador, Nova Scotia and the Federal Government to add data holdings from those provinces.
- The provincial electronic databases and the future national database can play a key role in occupational epidemiology studies, surveillance of temporal-spatial trends in workplace exposure, and evaluating policy change and other interventions.

EXECUTIVE SUMMARY

Many countries already have occupational exposure databases to support both research (for example, exposure assessment for epidemiology) and policy initiative (for example, prioritizing targets for intervention work). Canada does not currently have a national occupational exposure database, but work by researchers initially engaged on the CAREX Canada project (a cancer prevention project) has led to the capture of over 400,000 occupational exposure measurements from many jurisdictions across the Country. However, Canadian occupational exposure holdings are widespread and much is only available on paper records. The objective of this project was to help build the Canadian Workplace Exposure Database (CWED) by enabling the capture and addition of exposure data from BC Ministry of Energy and Mines (BCMEM) and the Government of Saskatchewan (SK).

Following small pilot studies to identify data sources at BCMEM, work began to abstract individual occupational exposure measurements and supporting supplementary data (e.g. on controls). SK data was principally abstracted direct from hygiene laboratory records, while BCMEM data came from hundreds of individual inspection reports. We abstracted 31,764 individual exposure measurements from the two data streams (22, 575 from BC Mines), covering a period of 1975 to 2011. All data were cleaned to remove errors, and standard coding was introduced for variables such as industry (NAICS 2002), occupation (NOCS 2006) and analyte. Approximately six percent of all data was “below limit of detection” (LOD). We collected complete data on chemical identity, concentration measure, units of measurement, date of sampling and Industry was obtained. Much other data was abstracted, but suffered from some degree of missing data likely because it was not deemed necessary for the data original use. Data for 58 and 190 substances were abstracted from BC Mines and Saskatchewan

sources, respectively. BC Mines data was primarily from metal mining. Saskatchewan data was from 19 different industry sectors, with the largest sector being manufacturing. The BC Mines and Saskatchewan exposure data add 7.5% more data to the Canadian Workplace Exposure Database, joining data from BC (Worksafe), Ontario, Manitoba, Yukon and Quebec. The Canadian Workplace Exposure Database Investigators are currently working with Alberta, Newfoundland and Labrador, Nova Scotia and the Federal Government to add data holdings from those provinces. In 2014 we will publish a discussion paper on the future of CWED with the purpose of obtaining data stewards input on the harmonization of data, policies and procedures for researcher and other stakeholder access, the nature and design of tools for using CWED as well as how to encourage the deposition of new data collection into the database. The provincial electronic databases and the future national database can play a key role providing exposure data for occupational epidemiology studies, surveillance of temporal-spatial trends in workplace exposure, targeting high risk populations, evaluating policy change and other interventions, and in determining what levels of exposure are “feasible” or “practicable”.

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1. BACKGROUND – Research Problem and Context

The Canadian Workplace Exposure Database (CWED) was created as part of CAREX Canada's Workplace Exposure Surveillance Project (1), with the goal to collect workplace exposure data from government agencies, researchers, and other sources and to create a large centralized (national) database that will house both current and historical exposure measurements from workplaces across Canada, similar to other national occupational exposure databases, such as the Occupational Safety & Health Administration's Integrated Management Information System (2) database in the United States. Initially, CWED was designed to support the investigation of carcinogen exposure in Canada, identifying which occupations come into contact with workplace carcinogens and to develop estimates of how many workers are exposed, where exposure happens, and at what levels exposure is thought to be occurring. But CWED also has broader practical application outside of the CAREX Canada project, and like other national exposure databases, it can become a useful tool for primary prevention of occupational disease, disease surveillance and workplace health research.

With partner PopdataBC, CAREX Canada developed a data acquisition agreement process and negotiated access to existing large electronic occupational exposure databases held in Canada by WorksafeBC, the Ontario Ministry of Labour and the National Radiation Dose Registry (NDR).

This current project reported here was aimed to support the identification, abstraction and transfer of additional data from other public agencies and/or other Provinces. It recognized that in some cases, archived occupational exposure data are very hard to access, for example in paper files or individual electronic reports, and that extra effort was needed to secure them for archiving.

Feasibility of further data addition to the CWED was carried out a pilot study. In March of 2009, a survey of main Canadian regulatory agencies was conducted to obtain a picture of the

quantity and quality of occupational exposure data. Please refer to Appendix A for a summary of information obtained from this survey. It was found that many of the regulatory agencies across Canada had large amounts of stored exposure data (3). However, we discovered that the majority of this data is stored in paper files (e.g. index cards) or unwieldy individual electronic reports (e.g. PDF reports). To be useful for statistical or other most other analyses, this exposure data had to to be reviewed by occupational hygiene experts, abstracted, coded and cleaned before being transferred into electronic databases.

1.1. Exposure Databases, a Background

Exposure databases provide an archive of historical exposure, and a benchmark of current exposure data knowledge, and highlight data gaps that may be important in future research or policy-making agendas. Large-scale exposure databases have been developed by many organizations in Europe and the United States (Table 1) but in Canada their development has been fragmented and slow. National exposure databases in other countries have been used successfully for many purposes. Databases developed from three occupational exposure surveys conducted by the US National Institute for Occupational Safety and Health (NIOSH) in the 1970s and 1980s have been a primary source of information for NIOSH, regulatory agencies, health professionals, and labor organizations in establishing priorities for prevention strategies, and have been linked to a variety of other databases to document workplace exposure trends (4). They have also been used by the National Toxicology Program to inform their annual reports on carcinogens, and in epidemiologic research examining diseases with long latencies, such as cancer (5). Germany's Institute for Occupational Safety has used its chemical workplace exposure database (MEGA) for the purposes of occupational disease investigation, epidemiology, and prevention, as well as to

inform discussions with other European exposure database holders about the establishment of EU limit values and the validation of exposure modeling for risk assessment (6).

Table 1: International workplace exposure databases *

Country	Database	Year initiated	Content	Chemical substances
UK	NEDB	1986	200,000 measurements	400+
Germany	MEGA	1972	1,000,000 measurements	420
France	COLCHIC	1987	400,000 measurements	600
US	IMIS	1979	>1,000,000 measurements	500+

*Adapted from 17,18

1.2. Exposure Data: Retention Practices

Large volumes of occupational exposure data exist and government agencies, industry and research groups generate new data all the time. Typically however, the data exists in private databases and is used one time for the purpose at hand and then archived. A study in the European Union showed that the largest fraction of such data collected by industry (44%) was kept for 5 years or less and that only 10% was kept indefinitely (7) emphasizing the need for such data to be preserved in a usable form.

CAREX Canada's survey of Canadian regulators showed that the record retention schedule across agencies was variable (3). Some agencies had already experienced substantial losses of exposure data. For example, contacts at PEI's Workers' Compensation Board and Alberta Human Resources and Employment claimed both destroyed nearly all of their exposure measurements collected prior to 1990. As neither have conducted government exposure monitoring since that time, there is apparently no accessible data from those provincial sources. In contrast, the BC

Ministry of Energy and Mines and Saskatchewan Ministry of Labour continued to store exposure data records dating back to the 1950s and 1970s, respectively.

1.3. Exposure Data: Collection and Storage Practices

Another practical issue of concern is the time frame of exposure data collection. Since the 1990s there has been a significant decrease in workplace exposure sampling performed by regulatory bodies across Canada - most surveyed agencies indicated that they are no longer responsible for collecting the majority of exposure measurements taken in their jurisdictions. Most provinces have legislation that permits hygiene officers to order employers to conduct exposure assessments themselves or via private consultants. Data obtained in this manner is usually kept on site with the employer and not recorded by the regulatory agency, resulting in greatly reduced centralization of provincial data since the 1990s in most cases. This has made the data less accessible from a research perspective.

Feasibility of data access varies widely across provinces, due to the variety of database formats used. Of all the agencies contacted to date, only the National Dose Registry, Human Resources and Skills Development Canada, and organizations in the province of Quebec maintain large computerized exposure databases. Others, such as the BC Ministry of Energy and Mines, and Workplace Health and Safety of Manitoba, Government of Saskatchewan, Yukon WCB, Service Newfoundland and WCB Nova Scoatia are presently storing their data in hard copy or individual electronic file formats only. Some agencies without electronic exposure databases commented that they were planning to implement them within the next few years; however initially their intent was that only prospective data would be entered (3).

Our finding that a significant volume of Canadian exposure data exists only in hardcopy form was not unexpected. An industry-wide search conducted across 13 industrialized countries in the mid-1990s for existing exposure measurement data showed that of 31,000 exposure measurements taken in the pulp, paper and paper products industries, only 10% were stored in fully computerized form, with an additional 24% in partly computerized form and 66% in manual form (8).

CAREX Canada's data holder survey findings point to the need for a national database of Canadian workplace exposure measurements, to preserve what remains of historical data and encourage the input of prospective workplace exposure data.

1.4. Strategies for Data Acquisition

Data acquisition for projects such as CAREX Canada's CWED uses several strategies. Existing data owners or data stewards have been enthusiastic to negotiate data sharing, so long as appropriate use and confidentiality are ensured. The data owner or steward can benefit from the numerous value-added opportunities. Data obtained in this way may be at the individual measurement level, or in an aggregated form so as to preserve confidentiality of individuals or agencies.

Beyond major data holders (such as ministries of labor, workers' compensation agencies, large corporations), identifying and abstracting data sources can be an expensive proposition. In a feasibility study conducted in the UK, researchers identified and tested 5 different strategies for retrieving data including contacting trade associations, consultants, major users and the ministry of defense. Over 800 organizations were contacted; approximately 9% had data and of these 74% were willing to provide the data. Total costs were estimated to range from £7 ($12 CAD) to nearly

£400 ($670 CAD) per exposure estimate for retrieving data from major users and trade associations, respectively (9).

Exposure data can also be gleaned from the scientific literature, but because of a variation in reported data sources, quality, etc., much is ineligible for exposure database use. For example, Caldwell *et al* (2001) reported retrieving 350 papers documenting hydrocarbon solvent exposure, but only 99 papers (28%) met the authors' criteria for quantitative analysis and of these, twenty percent were deficient with respect to the summary statistics reported (10). Individual level data, such as that obtained directly from inspection reports, provides more flexibility in its use potential than aggregate (i.e. averaged) data.

The goal of this research was to enable the transfer of large volumes of Canadian exposure measurement data - for carcinogenic as well as other disease causing agents – into searchable electronic databases, so as to be available to inform various levels of research, primary prevention, and policy. This work has focused on data held by the BC Ministry of Energy and Mines, and the Saskatchewan Ministry of Labour. In addition the grant supported continuing development and expansion of the CWED through negotiating agreements with additional partners such as Manitoba, Alberta, the Yukon Territory and feasibility assessments and pilot work with others such as Nova Scotia and Newfoundland and Labrador.

2. METHODOLOGY

2.1. General strategy

Prior to data transfer, memoranda of understanding were negotiated with BC Ministry of Energy and Mines (BCMEM) and the Saskatchewan Government to specify issues of confidentiality, use and access.

With respect to both Saskatchewan and BCMEM, the initial processes were similar. Identifying source material containing potentially valuable occupational exposure data can be problematic, but In the case of Saskatchewan, the task was simplified as exposure measurements were handled through a central laboratory and the project had access to the laboratory records. In the case of BCMEM, potential data sources were more diverse. CWED investigators visited BCMEM and reviewed archived files suspected of containing occupational exposure data, identifying those file types that were of potential interest. An Occupational Hygienist employed by BCMEM reviewed archival indices and selected archived file boxes of data holdings most likely to hold exposure data records. All file boxes were shipped to secure offices at UBC where every file was reviewed by a CWED Occupational Hygienist and relevant data identified for data abstraction.

2.1.1. Developing agency-specific databases

For each collaboration, a copy of the standard CWED database was created to reflect specific idiosyncrasies of the new data or requests of the data owner. Agency specific data entry rules were created based on the format and content of the data to be abstracted with the help of agency staff.

2.2. Data Entry

Standardized data entry procedures were performed. All data-entry was done using a data base front-end built for the project that guided data abstraction and performed primary validation tests. Training materials were produced for data entry Staff. Source boxes/files were coded and cross-referenced to each data entry record so that the original paper file could be located in the event of future need. Only single measurement observations were abstracted, not aggregated data (i.e. in the database, each measurement is represented by a single record (row)).

2.2.1. Saskatchewan Government

The abstraction of data was carried out by undergrad co-op students hired through the University of Saskatchewan's co-op program. Students were provided training, and were supervised by 3 Gov't occupational hygienists. The majority of data abstraction was performed on-site at the Saskatchewan Gov't Occupational Health and Safety Branch's secure offices, in Regina. All data was entered into secure gov't computers. Offsite work was performed in a secure environment using a password protected computer that implemented full hard drive encryption to protect Ministry of Labour Relations and Workplace Safety data from unauthorized access.

2.2.2. BC Ministry of Energy and Mines

Data from the Ministry contained in file boxes was requested from Ministry storage and transferred to UBC. A UBC research assistant was hired to perform data abstraction/entry in May 2011 -March 2012. Following project-specific training, she was provided with daily supervision by an occupational hygienist; frequent consultation was required as data supplementary to the

exposure measurement was often elsewhere in the report. All data entry work was conducted on site, in a secure environment, on password-protected computers.

2.2.3. Data Cleaning, Standardizing Language, Coding

Data quality issues were addressed where possible, including internal inconsistencies (i.e. invalid unit for substance type), missing values, inconsistent phrasing (same substance spelled different ways), same substance measured using different analytical techniques, etc. Original (raw) data was always retained, and new variables created with "cleaned" values, meaning no data was lost. Where different units of measurements (e.g. PPM and Mg/M^3) were used for the same substance these were standardized, if possible. Data were given new codes to logically group them by toxicological category (e.g. Chromium-6 was grouped separately from other chromium species).

2.2.4. Industry Codes

Using the Company name, that was abstracted, we coded the most appropriate standardized industry type using the "North American Industry Classification System Canada" (NAICS 2002) system to the 4- and 6-digit levels.

2.2.5. Occupation Codes

Where provided in original data, we used the job title and task information to code the most appropriate standardized occupation using the "National Occupation Classification 2006" (NOC 2006) system.

2.2.6. Data below Limit of Detection

A uniform code of “9999” was assigned in the concentration field for samples below detection limit, and the limit of detection (LOD) was recorded, as well as the unit of measurement for the LOD value. Thus decisions regarding how to interpret <LOD measurements in future analysis is left to the analyst (e.g. replacement with LOD/$\sqrt{2}$).

2.2.7. Quality Assurance

A minimum of every 50th observation (2% overall) was double data-entered by a second research staff person. Issues arising from quality assurance checks were discussed and procedures changed to improve data entry. Rate of checking was increased when a new data entry person was used.

2.3. Privacy and Confidentiality

In accordance with the Memorandum of Understanding put in place for this project, no individual level identifiers (persons’ names etc.) were abstracted. Where individual level identifiers existed, they were used to assign an anonymous person-identifier so that repeated measures on an individual can be identified, even though anonymity is preserved.

Only CAREX Canada and CWED investigators and employees had access to the data.

3. RESULTS

3.1. Data Summary for Each Stream

The number of measurements collected by each of the study streams are presented in Table 2. The data samples were originally collected between 1975-2011 and 1978-2009 for Saskatchewan government and BC Ministry of Energy & Mines (BCMEM), respectively. The BCMEM data consisted of 5,083 personal samples (990 for Saskatchewan data). One thousand, seven hundred and sixty seven observations in the Saskatchewan data were for non-air samples (bulk asbestos, noise, biological samples, etc.) and have been excluded from further reporting here. "Less than LOD" refers to "non-detects" where the amount of analyte obtained was too little to be detected by the analytical method. LOD was known for 405 (30%) of BCMEM measurements. Further work is need to determine LOD's for the remainder and all SK measurements < LOD. "Suspect sample" means that some aspect of the sample may limit its usability in analysis.

Table 2: The number of measurements collected by data source

Data source	Date Range	Measurements collected	Less than LOD	Suspect samples
Saskatchewan government	1975-2011	9189	499	-
BC Ministry of Energy and Mines	1978-2009	22575	1326	82

3.2. Abstracted variables

Table 3 shows the data that was available for abstraction. For all measurements for both sources, we abstracted a minimum of (i) chemical identity and (ii) concentration measure (iii) units of measurement, (iv) and date of sampling. For the large majority (and all of Saskatchewan) we also obtained Industry, Company name/Industry. For BCMEM, there was apparently good coverage of "Ventilation", but the large majority of entries are "unknown". For Saskatchewan, there was fairly good coverage of sample duration and volume (90% present). For all other variables (grouped in Table 5 under "sample characteristics", "company identification", "measurement", "occupation identification", "exposure control" and "other') there was some degree of missing data. This was to be expected as these "missing" data were probably not required for the initial use of the data. In addition we added a cross-reference variable to allow a user to go back to the original paper file if necessary.

Overall, data on 58 different substance categories were collected for BCMEM and 190 substances for Saskatchewan. Table 4 shows the frequency of sampling for those substances with at least 100 observations. Less diversity in chemical is evident in the BCMEM data presumably reflecting the more homogeneous work environment.

Table 3: Data Content abstracted from BC Ministry of Energy and Mines and Saskatchewan Government records.

		BC Ministry of Energy and Mines		Saskatchewan Government	
Type	Description	Present?	Missing Values	Present ?	Missing Values
Sample Identifier	Sample ID from original record	√		√	
	Year of measurement	√		√	
	Month of measurement	√		√	
Company/ Industry	Company name (text)	√		√	
	Name of company Site	√			
	4-digit NAICS	√	408	√	
	6-digit NAICS	√	408	√	
	Location of company	√			
	Industry in Text	√		√	
Occupation	Job title as provided	√	19843	√	8354
	Task performed during sampling	√	16171		
	NOC 2006 code	√	19843	√	8354
Measurement	Substance measured	√		√	14
	Exposure measurement	√		√	7
	Units for measurement value	√		√	7
	Average, peak etc.				
	Type of sample: Area/personal	√	1361	√	
	Duration of sampling	√	17445	√	716
	Start of sampling	√	17445		
	End of sampling	√	17445		
	Volume of air sampled	√	21302	√	1002
Controls	Ventilation (in use/present?)	√	9		
	PPE used?	√	16444		
Notes	Sampling Technicians notes	√	6459	√	1981
	Detailed location of sampling	√	1671	√	8849
	Analytical method			√	8309
	Anonymous Worker ID	√			
	Lowest detectable level	√	22095		
	Reason for Sampling			√	6667
	Source			√	2
	Direct Reading Instrument			√	
	Sample Type			√	
	Type of Mine	√	22440		

Table 4: Number of Entries by Substance and by data source (alphabetical order, only substances with at least 100 observation in one or both of the sources are shown)

Substance Name	Number of Entries	
	BC Mines	Saskatchewan
Acetone	0	129
Asbestos	2405	566
Calcium and its compounds	159	29
Coal dust	150	61
Chromium and its compounds	11	121
Copper and its compounds	162	56
Diesel engine exhaust	274	2
Petroleum distillates (Naphthas, Hydrocarbons)	0	926
Dust (inhalable)	0	1477
Dust (Respirable)	13760	0
Dust (unspecified)	2108	71
Iron and its compounds	7	132
Flour dust	0	154
Fluranes (anesthetic gases)	0	110
Formaldehyde	0	627
Glutaraldehyde	0	155
Isocyanates	0	102
Manganese and its compounds	11	100
Lead and its compounds	495	387
Silica	1435	110
Styrene	0	291
Toluene	4	517
Welding fume	120	213
Wood dust	2	223
Xylenes (Dimethylbenzenes)	0	509

3.3. Data summary by year

Figure 1 describes the measurements counts by period and by data source. Most of the measurements from BCMEM were taken between 1975 and 1985 whereas Saskatchewan government data was collected at a steady rate between 1975 and 2005.

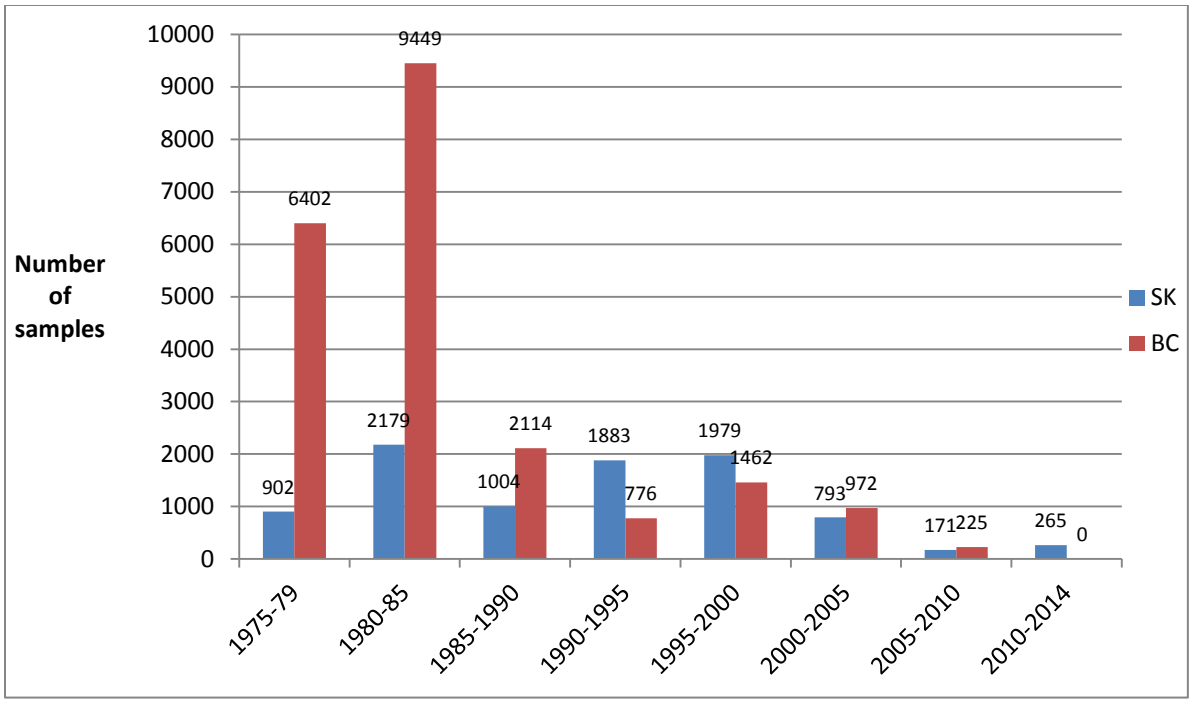

Figure 1: Measurements count by period and by data source

3.4. Data summary by industry and by occupational groups

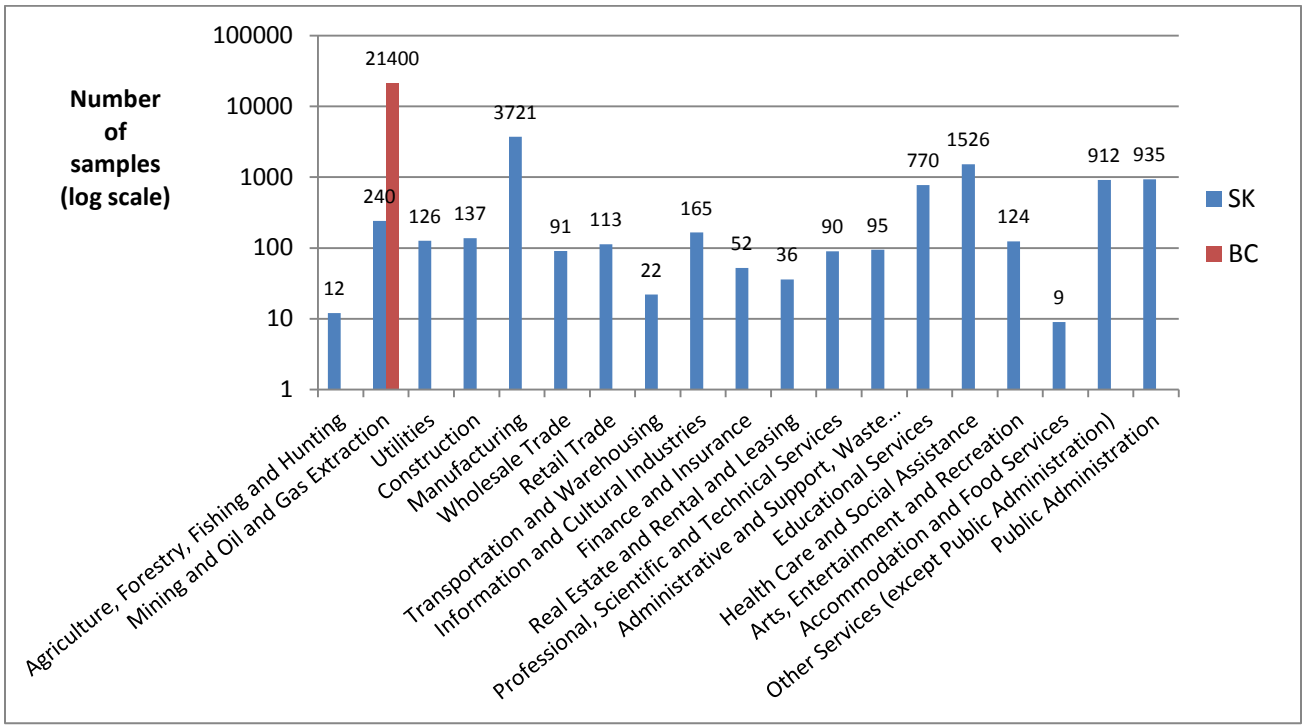

Figure 2: Measurements count by industry sector

All BCMEM data was within the NAICS Industry sector of Mining, oil and gas (Figure 2). Within this, the breakdown was Coal mines (NAICS 2002 code 2121) 1,555; metal metals (2122) 14,562 and quarries (2123) 6,050. Saskatchewan data was spread over 19 industry sectors, with the most prevalent being Manufacturing (NAICS 31-33). Number of measurement by Occupation is provide for BCMEM (Table 5); Occupation code was only available for <10% of Saskatchewan observations (not shown).

Table 5: BC Mines measurement entries by specific occupational categories for the 8437 observations with occupation specified.

Occupation category	NOC 2006 Occupation Code	Sample count	Proportion
Underground Production and Development Miners	i131	1649	19.5
Geological and Mineral Technologists and Technicians	c112	1476	17.5
Heavy Equipment Operators	h611	1461	17.3
Machine Operators, Mineral and Metal Processing	j121	1185	14
Drillers and Blasters	h622	592	7
Underground Mine Service and Support Workers	i141	386	4.6
Central Control and Process Operators, Mineral and Metal Processing	j111	387	4.6
Truck Drivers	h711	281	3.3
Welders and Related Machine Operators	h326	237	2.8
Labourers in Mineral and Metal Processing	j311	184	2.2
Mine Labourers	i214	148	1.8
Construction Millwrights and Industrial Mechanics	h411	91	1.1
Material Handlers	h812	81	1
Heavy-Duty Equipment Mechanics	h412	74	0.9
Industrial Electricians	h212	59	0.7
Supervisors, Mining and Quarrying	i121	53	0.6
Contractors and Supervisors, Mechanic Trades	h 16	32	0.4
Steamfitters, Pipefitters and Sprinkler System Installers	h112	36	0.4
Carpenters	h121	25	0.3
TOTAL		**8437**	**100**

3.5. Data summary on exposures and trends for selected substances

Extensive analyses were not performed as part of this project, which was primarily intended to capture data. Here we show demonstrate data utility however through examination of tie trends in exposure levels and some knowledge gap analyses. Figures 3 and 4 demonstrate time trends analysis for two substances common to the two data sources (BCMEM and SK). Welding Fume (Fig 3) had approximately 50 and 210 observations for BCMEM and SK, respectively. Both sources show some variability but with an overall decline with time. Figure 4 shows the same thing for crystalline silica. BCMEM data shows a fairly consistent mean exposure over time while the SK data shows an apparent increase in levels over time. In fact this is likely because later measurements were mostly from a single company, perhaps biasing the result as it may not be representative of the whole province. Silica levels by industry (Figure 5) for SK meanwhile shows mean silica levels by industry but doesn't necessarily reflect changes in exposure over time. Modeling would be preferred to concurrently analyze such trends over time and industry but significant amounts of data would be necessary – one benefit of having a national data resource over many smaller regional resources.

In order to demonstrate use of the data in identifying possible knowledge gaps, we asked the question "where are people most heavily exposed to carcinogens? Is there exposure data in those industries?". We took prevalence of exposed workers from CAREX Canada (1) and the number of measurements from the newly acquired data. The resulting metric is a rate: the "number of exposure measurements per 1000 carcinogen-exposed person". The results for Saskatchewan and BC Mines are shown in Figures 6 and 7, respectively.

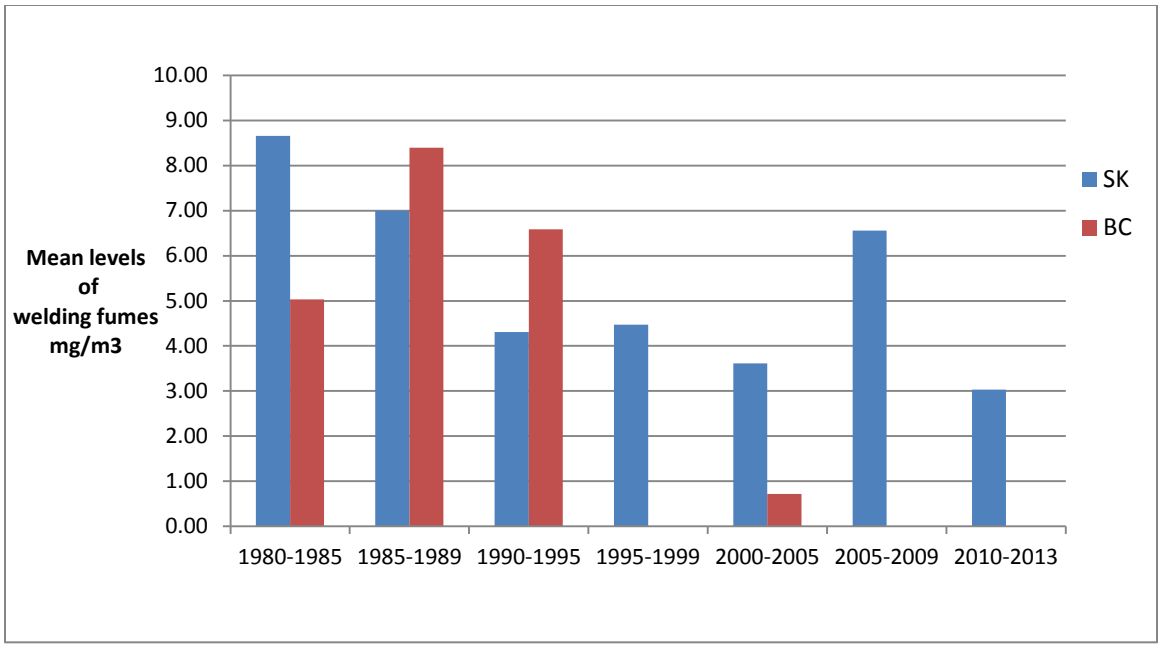

Figure 3: Trends in mean Welding fumes levels by data source

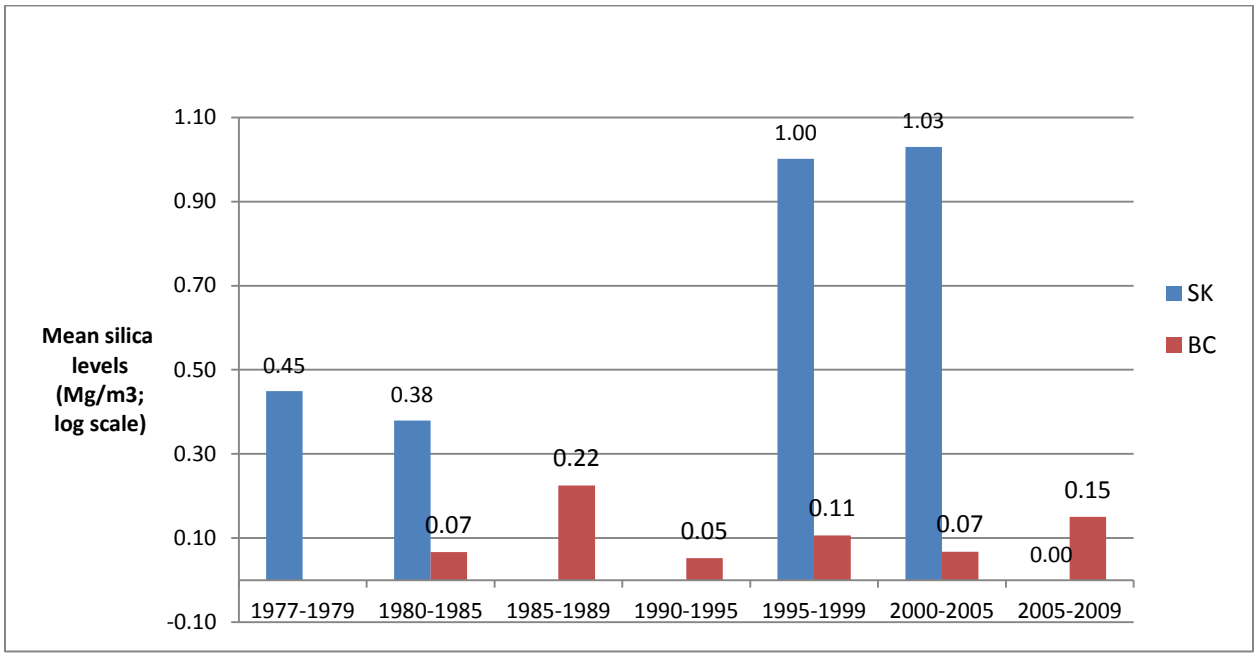

Figure 4: Trends in mean Silica levels by data source

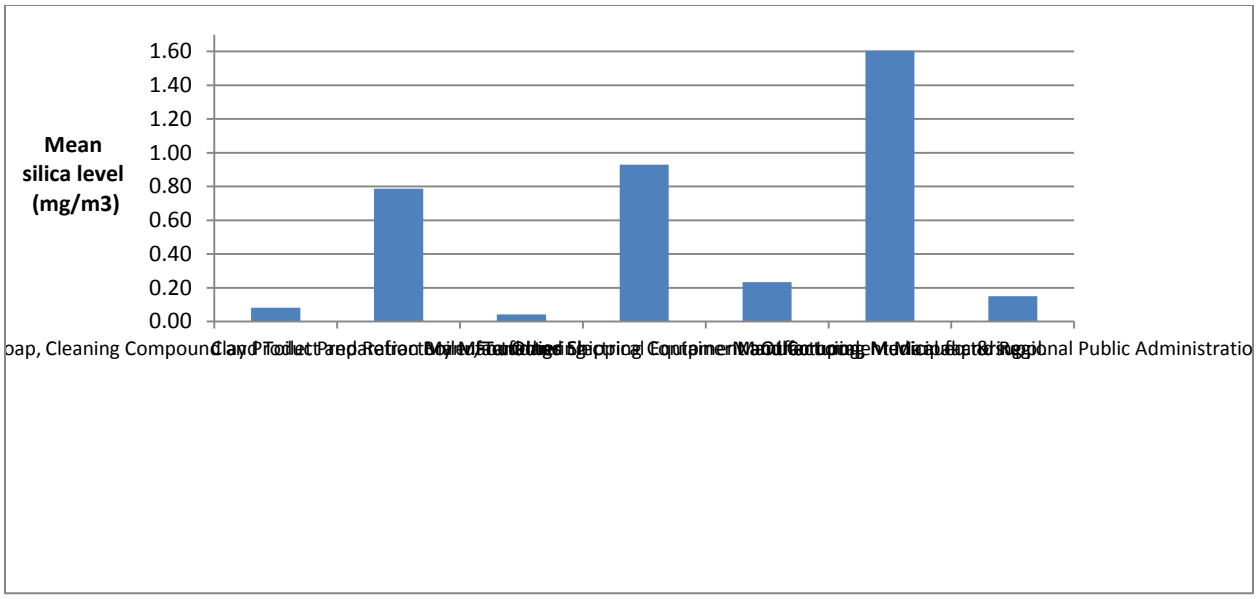

Figure 5: Saskatchewan silica levels by industry

While the metric is somewhat abstract, it does demonstrate the variability in exposure surveillance rates for different chemicals in different industries; we see very low levels of silica exposure surveillance in SK Construction (where we would expect exposure to be widespread) compared to say manufacturing. Silica surveillance also appears low in mining, compared for example to the effort made for asbestos. Of course this metric does not tell the whole story, but is one way by which to identify potential knowledge gaps that should be investigated further to see if increased exposure surveillance efforts are warranted.

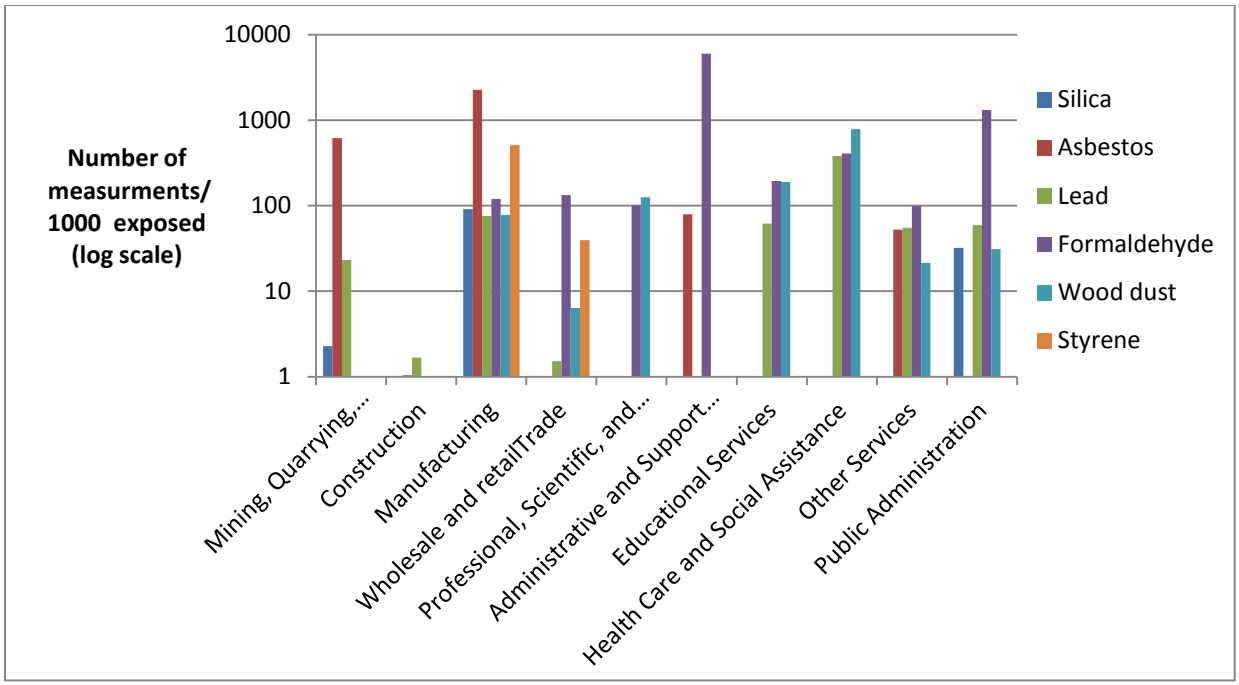

Figure 6: Number of Saskatchewan measurements in relation to CAREX data of exposed persons

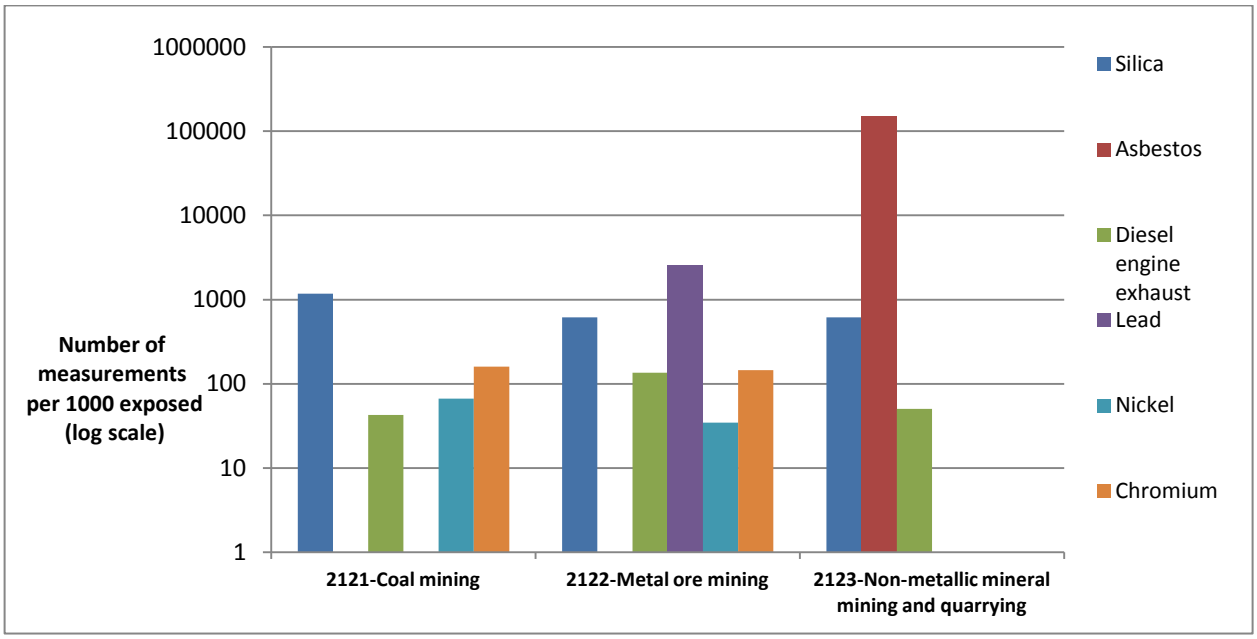

Figure 7: Number of BC Mines measurements in relation to CAREX data of exposed persons

4. CONCLUSIONS

In conclusion, we consider the project a success. Almost 35,000 occupational exposure measurements were digitized, cleaned and coded and added to the Canadian Workplace Exposure Data base (CWED). This represents an addition of 7 % of the total CWED holdings at the time of writing.

The abstraction cost per measurement was less than $4, which compares very favourably with the costs observed in similar efforts; a UK study estimated £7 (GBP) per measurement using their most cost-effective method (9). We concur with the authors of that study that *prospective* data entry would be an even cheaper option, and particularly if it was ensured that all appropriate supplementary data was collected coincidently. Regardless, there are additional costs associated with cleaning and coding even data that was collected electronically. These costs relate to harmonizing the data across jurisdictions by standardizing coding, etc..

Of the 35,000 measurements abstracted, complete data was available for only a subset of the potential variables (company, date, substance, concentration and units). All other variables suffered some degree of missing values. This was to be expected, as the purpose of the original data collection varied. With no standardized data collection procedure anticipating future needs, the kind of data collected was also highly varied. Nevertheless, partial data was collected for variable occupation (40% available), Task (29%), duration of sample (63%), etc. in a useful numbers. Exactly what data should be considered “key” has been widely debated and varies depending for the kind of research/surveillance being done (11). Industry and exposure

data is sufficient for CAREX Canada purposes, for example; however to be useful in assessing interventions, additional data on control (ventilation or PPE) would be required.

There are other limitations of the data. While not specifically recorded, it can be assumed that the majority of the data were taken for compliance purposes and therefore measurements might be biased toward higher exposures. However examination of exposure databases comprising data collected for multiple purposes seems to suggest that that bias may not be great (11b).

Even with 10's of thousands of measurements however, many data gaps remain, especially when you begin to stratify by year, substance, industry, etc.. A benefit of a national resource is that these empty "cells" might be populated with data from another jurisdiction.

This project has research implications at the agency, province and national levels. For the agency (i.e. BC Ministry of Energy and Mines and the Saskatchewan Ministry of Labour or Worksafe Saskatchewan), occupational exposure measurement data is now available in a digital form that permits them to undertake enquiries and analyses that would not have been feasible while the data was only in paper form.

The availability of provincial and national databases of occupational exposure data is an important tool in improving exposure assessment for epidemiology (12). Objective measurements rather than subjective estimation are desirable to reduce exposure misclassification. But for population-based studies (particularly case-control), the breadth of industries, occupations and time periods for which quantitative exposure data is required can only be feasibly achieved with a very large comprehensive exposure database.

The CWED offers baseline data, and can contribute to an enhanced understanding of the trends in occupational exposures across time, which is of special interest when trying to understand the effective of policy change and interventions (13). It is rare that a single study or single workplace would collect enough exposure data over time to be able to undertake such an analysis, while provincial exposure data resources – and even better, national exposure data resources – permit not only examinations of the temporal trends but also spatial trends. These are important in Canada where there can be evaluation of the various provincial OHS regulation and policy is aided by the ability to simply compare exposure levels across jurisdictions.

Another important role for occupational exposure data is in the understanding of the burden of occupational disease in Canada. The Canadian Workplace Exposure Database group is collaborating with the Occupation Canada Research Center in Ontario to estimate the cancer burden attributable to occupational exposures (14). That project will help raise awareness of occupational exposure as an important causal factor in cancer etiology and their results will be useful in highlighting priority areas for prevention activities. By projecting estimates forward, it will be possible to demonstrate the impact reducing exposure to specific substances on future cancer rates.

With respect to the abstraction of the BC Ministry of Energy and Mines data, this is very timely as the province is undergoing considerable expansion in this sector, with a large increase (over 230%) in the number of persons employed over the past decade (15). CWED is assisting (database design information and expert support) in an Ontario initiative undertaken by the Occupational Cancer Research Center (Toronto, ON) to digitize all occupational exposure data

for Ontario mines (16). We are also in negotiations with the Newfoundland Government (Service Newfoundland) to establish a new project to digitize all of their archived exposure data, the majority of which is from the mining sector. Combined, this will represent an important resource for researchers trying to understand and mitigate occupational health risks in mining in Canada.

Table 6: Policy and Prevention Implications of the Canadian Workplace Exposure Database

- Targeting high risk groups
- Setting priorities for prevention-related activities
- Monitoring trends in exposure over time
- Assessing the impact of regulations
- Determining what is reasonably achievable
- Predicting future cases of disease
- Educating the public and policy makers
- Improving risk assessment

There are many policy and prevention implications resulting from the development of CWED (Table 6). As noted previously, having the data in digital form make it much easier to monitor trends in exposure over time and space and other variables (such as industry) as we demonstrated in Figs 3-4. This is helpful in order to examine the long-term impacts of major policy change, or intervention. Because the data coding is also standardized with respect to substance name, industry code, etc., it becomes easier to make external comparison with international data. The data is useful for targeting high-risk groups, i.e. those where exposure levels are high (and not adequately controlled) and/or when there is new knowledge about a substance (for example a chemical is added as an IARC carcinogen), or TLV's are changed. The data can aid in setting priorities for prevention-related activities where high risks are identified, and where data may be lacking. For example we showed how we could examine data or knowledge "gaps", by comparing prevalence of carcinogen exposures in Saskatchewan as

estimated by CAREX Canada with the number of sampling measurements made for the same carcinogens. In this case we saw that compared to formaldehyde other common carcinogens such as benzene and silica are far less likely to be tested, while diesel exhaust and PAH's – representing 20% of occupational carcinogen exposures in Saskatchewan had no data at all in the database.

An important concept in controlling occupational exposures is that of what measures are "practicable" or "reasonably achievable". A good test of this is to be able to see what exposure levels are being achieved in other, similar, settings other industries, companies, provinces. Such information is potentially available from such a resource as CWED, making it a potentially powerful tool for both the policy analyst and the field hygiene officer.

We mentioned earlier the CWED collaboration on a burden of occupational cancer project with the OCRC. Predicting future cases of has important policy implications for targeting OHS policy but also health service planning and the prioritizing of medical resources, and economic analysis and the appropriate attribution of costs associated with occupational disease. While the current project only deals with cancer, it is envisioned that similar "burden of disease" projects could be undertaken for other common occupational disease such as respiratory, neurological or dermal.

5. Future Work and Recommendations

This project is one in a series that has enabled the investigators to digitize occupational exposure data from across Canada for inclusion in a national exposure database – while

"mobilizing" the data for the data owner, with the intent of making the data more useful to them in their own work.

While some of the potential benefits of the project are immediate, for example the use of data by the data owners and by CAREX Canada, additional work is needed in order to fully realize the national Canadian Workplace Exposure Database (CWED) resource.

Residents of BC and Saskatchewan will therefore continue to see benefits from this project, as that work proceeds. Currently, CWED is finalizing data acquisition for projects in Newfoundland and Nova Scotia, and are in discussions with the Federal Government (Human Resources and Skills Development Canada) for exposure data on industries under federal regulation. Concurrently we are working with the over 420,000 data points already in CWED to standardize across multiple discrete "provincial" (or agency) databases and create an integrated national database. We are working on developing tools to allow researchers and policy-makers access to the data, as well as developing policy and procedures to ensure data access meets all necessary privacy and confidentiality laws and requirements of the data owners. As part of this development the CWED group will publish a "discussion paper" in 2014 (at or before the Canadian Association for Research on Work and Health conference in Saskatoon in October 2014) that will outline in greater detail the steps necessary to creating CWED as a national resource. The discussion paper will cover issues around what data is stored, privacy and confidentiality, data access, updating the database with new data, and access tools and protocols. Following publication of the discussion paper and a period of review, CWED will coordinate a national (likely web-based) workshop to discuss the proposals made in the

document. We will invite and encourage BC and Saskatchewan agencies to continue to be a part of the development of the Canadian Workplace Exposure Database (CWED) and we will forward copies of the forthcoming discussion. Specifically with respect to relevant agencies in BC and SK, we will continue to communicate projects updates, including database updates (such as coding improvements) and data analyses (such as re-estimating CAREX Canada estimates of carcinogen exposure prevalence using BC and SK exposure data). We also hope to continue to work with BC and SK agencies on the development of new procedures and tools to enhance the value and utility of occupational exposure databases. It is our hope that in the future we will encourage data sharing with industry and other data stewards, which would help address the problem of potential bias in the data coming only from regulators, and also make the data more generalizable. Finally we encourage WorksafeBC and the Government of SK to continue to collect occupational exposure data, and to digitize it as collected as this is most cost-effective. We also recommend that careful consideration be given to the supplementary data that is collected at the time of sampling. The "key" variables that we have identified for inclusion in the CWED are shown in Appendix B. This should be considered the minimum that is collected, but additional data may be required depending on the proposed use of the data.

6. Knowledge Transfer summary

6.1. Conference presentations related to Canadian Workplace Exposure Database

- Davies, HW, C Peters, A hall, PA Demers, Canadian Workplace Exposure Database (CWED): Past, Present and Future; Accepted, CARWH Conference, Saskatoon, Oct 19th, 2014

- Hall AL, Peters CE, Davies HW, Demers PA. "Occupational exposures in veterinarians: findings from a national surveillance project (CAREX Canada)." 23rd International Conference on Epidemiology in Occupational Health EpiCOH meeting, June 18-21 2013, Utrecht, Netherlands. Oral presentation.

- Demers, P, C Peters, H Davies, J Kim, M Pahwa, C McLeod, AM Nicol, F Labreche, J Levoue, S Hutchings, L Rushton; Incorporating more detailed exposure assessment with quantitative estimates is assessing the burden of occupational cancer. Occup Environ Med. 2014;71 Suppl 1:A51. 24th International Conference on Epidemiology in Occupational Health EpiCOH meeting, June 2014, Chicago
- Hall, A., P Demers, C Peters, **HW Davies** "Establishment of a national Canadian workplace exposure database: progress and challenges", EPICOH, Oxford UK, Sept 2011
- Hall, A, P Demers, C Peters, **HW Davies** Progress in the Development of a Canadian Workplace Exposure Database, American Industrial Hygiene Association Conference and Exhibition, Portland OR, May 2011

6.2. Peer Reviewed Papers

- Hall, AL., C. Peters, HW Davies, PA Demers, Occupational Exposures in Canadian Veterinary Settings: Findings on antineoplastic drugs and ionizing radiation from a national surveillance project; Can J Pub Health, 2013, 104(7): e460-e465
- Hall, AL., C. Peters, PA Demers, HW Davies; Exposed! Or not? The diminishing record of workplace Exposure in Canada, Can J Pub Health, 2014; 105(3):e214-e217

6.3. Website development

See new Canadian Workplace Exposure Database website at http//:cwed.spph.ubc.ca .

6.4. Development of continuing research through national collaboration

Consistent with the objectives of this project, we have made significant efforts to establish new collaborations with other Canadian owners of Occupational exposure databases. To this end we have made 2 visits each to meet with representatives from WSCC and Service Newfoundland in Saint John's, NL, and with WCB Nova Scotia in Halifax NS. Both are currently at the stage of inventorying potential exposure data for inclusion into the CWED. In addition we

are in discussions with the Federal Government (Employment and Social Development Canada) with respect to obtaining their hygiene laboratory records.

6.5. Other CWED/CAREX knowledge transfer work during study period.

See Appendix C.

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APPENDIX A

Summary of Survey Information obtained from Canadian Data Holders

Location	Organization	Exposure data collection Timeframe & Quantity	Exposure Measurements (Hard copy/individual electronic)	Exposure Measurements (Electronic database)	Bodies responsible for current data collection	Targeted Industries or Exposures	Data Storage Format & Retention Schedule
DATA ALREADY HELD BY CAREX CANADA							
BC	Worksafe BC	* Data from 1981 to 2004 already held by CAREX Canada	N/A	110,000	No current data collection	N/A	* Electronic database held by CAREX Canada
ON	Ministry of Labour	* Data from 1980 to 1995	N/A	* >300,000 (75,000 CAREX priority)	No current data collection	?	* Electronic database held by CAREX Canada
QC	Commission de la Santé et de la sécurité de travail	* SMEST: 1995-2000 * HYGIENE: 1976-1992	N/A	* SMEST: ~5000 * HYGIENE: ~3000	* See additional information for Quebec below		* Electronic databases held by CAREX Canada
NL	United Steelworkers Union	* 1976-1994	N/A	* 6,000 in electronic database	No current data collection	Mining	* Electronic databases held by CAREX Canada
CAN	National Dose Registry	* Started in the 1940's* Currently > 150,000 workers monitored at > 25,000 worksites * Contains radiation exposure data for	N/A	* Aggregated data for >150,000 workers in electronic database	Radiation Protection Bureau of Health Canada	Data for all monitored workers' exposure to radiation in Canada	* Individual dosimeter measurement data, cumulative dose * Individual information, employer names and locations

		>550,000 workers					
DATA TO BE OBTAINED BY CAREX CANADA							
SK	Ministry of Labour, Occupational Health and Safety Division	* Collected since early 1970s * 600-2000 samples/year until early 1990s, now around 100/yr	* 20,000 to 40,000	* 1,000	Government Hygienists, Employers, Private Consultants	* A mix - often related to regulatory amendment cycles	* Approximately 30,000 measurements on index cards * Last 9 years' worth of data recently entered into LIMS-style database
BC	BC Ministry of Energy, Mines and Petroleum Resources	* Collected since 1950s * 125 boxes of hard copy files	* 20,000+	N/A	Government Hygienists, Employers	* Silica, lead, cyanide, welding fume	* Thousands of measurements on paper
YT	Workers Compensation Health and Safety Board	* Asbestos since mid-1980s * 200-300 samples/year	* 5,000 to 8,000	N/A	Government Safety Officers	* ~50% of sampling is for asbestos clearance * Lead, zinc, mold	* Plan for a fully functioning database by 2011 * Asbestos measurements kept 25 years minimum * Other measurements kept 8 years
DATA ACCESS NEGOTIATIONS IN PROCESS							
CAN	Human Resources Services Development Canada Industrial Hygiene Laboratory	* Obtain 2000 measurements from across Canada per year	* Uncertain	* ~44,000	National Labour Operations Directorate staff	Grain dust, welding fumes for interprovincial trucking companies, railroad	* Older data on paper files may be available * Data predominantly freeflowing text * Electronic database is being updated
NS	Labour and	* Collected from late	* Uncertain	* Uncertain	Government	N/A	* Majority paper & MS

	Workforce Department	1970s to 1996 * Yearly average number of samples taken uncertain			Hygienists, Employers, Private Consultants		Word documents * Recent prospective electronic database by individual employer * Retention schedule uncertain
NB	Workplace Health, Safety and Compensation Commission	* Data is collected only if an inspector orders an employer to have the workplace tested by a 3rd party. This limited sampling happens 1-2 times per year	* Uncertain	* Uncertain	Employers, Private Consultants	* Occasionally target industry - welding in metal fab to examine ventilation * Future: Wood dust, lead & formaldehyde?	*~20 yrs back - not sure if logging hygiene data * Only gov't hygienist results *1997-8ish - started logging online
QC	Commission de la Santé et de la sécurité de travail	* 1976 to present * 30,000 to 50,000 samples collected every year	* 1 million in hard copy	* In CAREX possession (see above)	IH teams from local public health centres (~15) over several administrative regions	Monitoring carried out at companies belonging to priority industries based on accident rates	* No intentional destruction of records
MB	Workplace Health and Safety	* Collected since at least 1980 * Yearly average number of samples taken uncertain	* 26,000 *employer files*	N/A	Workplace Health & Safety, Employers, Private Consultants	Formaldehyde, glutaraldehyde, isocyanate, hexavalent chromium	* Before 1990 - hard copy, then individual electronic files for employers created
DATA HOLDINGS SCANT OR NON EXISTENT							
AB	Alberta Human	* Collected up to early	N/A	N/A	Employers, Private	Oil & Gas	* Archive retention estimated at under 10

	Resources and Employment, Workplace Health and Safety	1990s			Consultants		years, therefore essentially no data retained
NL	Government Services OHS Division	* Never collected by OHS Division; when inspections ordered, gov't hygienists review reported data	N/A	N/A	Employers, Private Consultants	N/A	N/A
NWT/ NUN	Workers Compensation Board	* Sampling is almost nonexistent	N/A	N/A	**?**	Diamond mines	**?**
ON	Workplace Safety and Insurance Board	* Do not collect exposure data	N/A	N/A	Employers, Private Consultants	**?**	N/A

Appendix B

CWED "Key" Variables

CWED Variable	Description
StudyGroupID	Study group identifier
SampleID	Unique identifier for each sample
SampleDate	Date the sample was taken
AnalyteCode (CAS, CCODE, AnalyteCode)	Code for substance being measured
AnalyteName	Name of the substance being measured
ResultValue	Sample result measurement value
ResultUnit	Unit of measurement for the sample result
Concentration	Calculated standardized concentration value
ConcentrationUnit	Unit of measurement for the concentration
AirVolume	Total volume of air sampled
Duration	Total time of sample
LimitOfDetection	Limit of detection
LimitOfDetectionUnit	Unit of measurement for the limit of detection
MethodCode	Analytical sampling method code
MethodDesc	Analytical sampling method description
NAICSCode	North American Industry Classification System (2002) code
NOCSCode	National Occupational Classification (2006) code
AreaOrPersonal	Location type of sample: Area, Personal, Unknown
Province	Province
QualControlDone	Quality control check completion indicator
OrigDataHolderID	Identifier of original data holder
DataHolderType	Type of organization holding the original data (regulator, industry, etc)
SizeFraction	Size fraction for particulate samples

CompanyID	Company code
CompanyName	Company name and other information available
CompanyType	Company type information
OtherSampleInfo	Other fields which add information about samples
ReasonForSampling	Reason for sampling
PersonalProtection	Type or sometimes just whether or not personal (or collective) protection equipment is used
WorkAreaDesc	Free form comments on work area
JobDesc	Job description information
Timing	Other fields with timing information
Ventilation	Type of ventilation in place
Eng_controls	Other engineered exposure controls?
Admin_control	Type of administrative controls in place?
PPE	Type of PPE in use

Appendix C

Other CWED/CAREX knowledge transfer work during study period

Organization	Description of engagement	Description of KT activity	How group is using CAREX
WorkSafeBC	Working group (established) to support occupational disease initiatives	Meeting on a bi-annual basis with multiple departments across the organization to support WorkSafeBC's prevention activities and analyses of occupational disease data	Used CAREX's BC exposure estimates and package summary to prioritize strategic planning on occupational disease prevention and identify gaps in outreach materials; now co-developing brief summary packages aimed at employers and workers
Canadian Cancer Society – BC/Yukon	Communications and prevention planning support to public issues team	Offering regular support with prevention planning and resource development	Used CAREX profiles on radon and asbestos to inform public education for homeowners and contractors; now using solar UV estimates to inform a campaign targeted at reducing sun exposure in outdoor workers
BC Federation of Labour *(Health and Safety Committee)*	Presentation to Committee and follow-up with labour group representatives on the committee as required	Offering follow-up presentations and package summaries on exposures to labour group representatives	Some labour groups from this committee are using CAREX in various ways (described below)
BC Building Trades *(Labour)*	Prevention planning support and training to prevention staff and occupational health and safety committee	Providing a package summary of priority occupational exposures for building trade workers in BC and offering training on eWORK	Using priority exposures identified via CAREX package and eWORK tool to guide which substances to focus on in exposure reduction efforts, ie silica
BC Teachers' Federation *(Labour)*	Support in making recommendations to executive on exposure reduction priorities for the province's teachers	Providing a series of presentations to various committees and developing a package summary on teachers' exposures at work	Using priority exposures identified via CAREX presentation to guide recommendations (for example, Health and Safety Committee recommended all schools in the province be tested for radon)

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