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REPORT **R-774**

Estimating the Costs of Occupational Injuries

A Feasibility Study in the Mining Industry

Martin Lebeau
Patrice Duguay
Alexandre Boucher

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Legal Deposit
Bibliothèque et Archives nationales du Québec
2013
ISBN: 978-2-89631-667-0 (PDF)
ISSN: 0820-8395

IRSST – Communications and Knowledge Transfer Division
505 De Maisonneuve Blvd. West
Montréal, Québec
H3A 3C2
Phone: 514 288-1551
Fax: 514 288-7636
publications@irsst.qc.ca
www.irsst.qc.ca

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This publication is available free of charge on the Web site.

This study was financed by the IRSST. The conclusions and recommendations are those of the authors.
This publication has been translated; only the original version (R-717) is authoritative.

ACKNOWLEDGEMENTS

We thank all the persons and organizations who directly or indirectly took part in the production of this report.

In particular, we want to thank Claude Fortin and Christian Simard of Xstrata Nickel's Raglan Mine and Yvan Ouellette of Arcelor Mittal Mines Canada.

We also offer our thanks to Jean Drolet of the Association paritaire pour la santé et sécurité du travail du secteur minier and Pierre Thibault of the Québec Mining Association for their cooperation and to the member companies for taking part in the study.

ABSTRACT

This study is part of the IRSST's effort to develop economic indicators in the occupational health and safety field on which, in combination with the indicators and other information already in use at the IRSST, decisions regarding research priorities can be based.

It attempts to clarify the feasibility of developing such indicators at the IRSST. To accomplish this, it tests, using available data, various methods for estimating the costs of occupational injuries and profiles these costs in the Québec mining industry during the years 2005 to 2007.

In broad terms, the study shows that it is possible to estimate the financial and human costs associated with occupational injuries in a specific industry. However, it also indentifies certain limitations that could affect the development of economic indicators at the IRSST.

The annual cost of occupational injuries in Québec mines is estimated to be approximately $130 million dollars (in 2006) or about 5% of the mining industry's contribution to Quebec's GDP. Of this amount, around $50 million is attributed to financial costs and $80 million to human costs. Due to the limitations of the methodology used, this is probably an underestimation of the costs of occupational injuries in the mines.

Analysis of the results also revealed that the workers assume nearly 67% of the total costs, largely in the form of human costs. For their part, the employers assume nearly 64% of the financial costs.

Various methods drawn from the scientific literature were used to estimate some cost components. First, the human capital method was used to estimate the productivity losses. Then a health status index was used in combination with the willingness-to-pay method to estimate, in monetary terms, the human costs caused by occupational injuries.

The most significant limitation on making this type of estimate is data availability. This limitation particularly affects estimation of the costs of injuries for employers. For example, several costs not insured by the CSST were estimated using information obtained from surveys of Québec mining companies or from a study carried out in a mining company.

This limitation is especially problematic when attempting to develop economic indicators for all Québec industries. When doing so, the IRSST will need to consider whether it is necessary to carry out the most complete estimate possible of the costs of occupational injuries or whether it can limit itself to the most significant cost components that use easily available data.

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GLOSSARY

Accepted injuries	This category of injury includes all the work accidents and occupational diseases recognized and accepted by the CSST, irrespective of whether there have been CSST-compensated days of absence from work, a PPMI, or a death resulting from the injury. Also included are cases without a CSST-compensated day of absence, only reimbursed fees and charges. In this study, the expressions *accepted injuries*, *occupational injuries*, and *accepted occupational injuries* are used interchangeably unless otherwise indicated.
AIAOD	Act respecting industrial accidents and occupational disease.
APSM	Association paritaire pour la santé et sécurité du travail du secteur minier, a joint sector-based occupational health and safety association for the mining industry.
CLP	Commission des lésions professionnelles, the administrative tribunal of last resort for workers and employers who are dissatisfied with a CSST decision.
Compensated injuries	This category of injury includes all work accidents and occupational diseases recognized and accepted by the CSST and for which there are compensated days.
Costs for employers	In this report, costs for employers are the costs specific to mining industry employers with injured employees as well as some general costs assumed by the other employers in the industry or by all Québec employers.
Costs for society	In this report, costs for society are defined as the total of the costs for employers, workers and the community.
Costs for the community	In this report, costs for the community are the specific costs borne by economic agents in society other than employers and workers, as well as the general costs assumed by society as a whole, including employers and workers.
Costs for workers	In this report, costs for workers are the costs borne by the injured workers and their families and friends.
CSST	Commission de la santé et de la sécurité du travail du Québec, the Québec workers' compensation board.
DALY	Disability-Adjusted Life Year. DALY extends the concept of potential life years lost due to premature death to include the

	equivalent in terms of life years in good health lost due to health problems or disabilities (WHO, 2011). One DALY equals one lost life year in good health.
Data maturity	The period between the date on which the injury occurred and the date on which the data used to calculate the indicators was last updated is called the data maturity period.
Disbursement	Total of all amounts paid by the CSST during the data maturity period for a claim from a worker who has submitted to the CSST an application for compensation that has been accepted.
Financial costs	All costs excluding human costs.
FTE	Full-time equivalent. It is either an estimate of the number of full-time equivalent (FTE) workers based on the hours worked during a year or the identification of an indicator calculated on the basis of such a force of workers (e.g. FTE frequency). A FTE worker is equivalent to 2,000 hours worked.
Human costs	The value of the change in the quality of life of the worker and those in his or her circle for the duration of such changes and, in cases of death, the potential years of life lost (e.g. pain, suffering and loss of enjoyment of life). In this report, human costs also include the indemnities paid to compensate for this type of harm; in addition, the expressions *human costs* and *pain and suffering costs* are used interchangeably unless otherwise indicated.
IRI	Income replacement indemnity. These indemnities are paid by the CSST to compensate for the loss of income when an interruption of work occurs due to an occupational injury or disease.
Manual occupations	Occupations in which physical activity plays a predominant role (construction jobs, unskilled labour, specialized workers, etc.).
Mining industry	In this study, the mining industry is considered to be formed of companies involved in mining and quarrying (except oil and gas extraction) as well as in support activities for mining and oil and gas extraction.
Mixed occupations	Occupations that require the performance of either light and continuous or intense but occasional physical activities (nursing personnel, haircutters, technicians, etc.).
NAICS	North American Industry Classification System.
Non-manual	Occupations in which physical activity plays a minor role

occupations	(administrative personnel, teachers, etc.).
Occupational category	Occupations are divided into three occupational categories—manual occupations, non-manual occupations, and mixed occupations—using an IRSST-developed methodology.
Occupational disease	A disease that is "contracted out of or in the course of work and characteristic of that work or directly related to the risks peculiar to that work" (AIAOD, s. 2). In this study, it refers more specifically to new occupational disease cases accepted by the CSST. Thus, recurrences, relapses and aggravations do not constitute a new occupational disease per se; instead, their consequences (days of compensation, costs, etc.) are accounted for with the original event when they are covered by a claim accepted by the CSST. In some cases, a distinction can be drawn between accepted and compensated occupational diseases. For an explanation of the difference between these two categories of occupational disease, please see the definitions for *accepted injuries* and *compensated injuries*.
OHS	Occupational health and safety.
PPMI	Permanent physical and mental impairment. Determination of the PPMI rate is based on a table of damages that is uniform for Québec.
QALY	Acronym for "quality-adjusted life year." A QALY takes into account both the quantity and quality of the life year gained. A QALY is equivalent to one life year gained in good health.
SEPH	Survey of Employment, Payrolls and Hours, a Statistics Canada form on which employers report payroll-related statistics.
VSL	Value of a statistical life.
Work accident	"A sudden and unforeseen event, attributable to any cause, which happens to a person, arising out of or in the course of his work and resulting in an employment injury to him" (AIAOD, s. 2). In this study, it refers more specifically to new work accident cases submitted to and accepted by the CSST. Thus, relapses, recurrences and aggravations following a submitted and accepted work accident are not considered to be a new work accident as such; instead, their consequences (days on benefits, costs, etc.) are accounted for with the original event when they are covered by a claim accepted by the CSST. In some cases, a distinction can be drawn between accepted and compensated work accidents. For an explanation of the difference between these two categories of occupational disease, please see the definitions for *accepted injuries* and *compensated*

	injuries.
WTP	Willingness to pay. The willingness-to-pay method consists of estimating the amount that an individual or society is prepared to pay or receive in exchange for a marginal change in risk (injury, disease or death).
YLD	Years lost due to disability, i.e. the number of years in good health that are lost due to a disability.
YLL	Years of life lost, i.e. the number of potential years of life lost.

1. INTRODUCTION

The mining industry is safer today than it once was. Indeed, recent years have seen a significant decline in the number of compensated occupational injuries[1]. However, the frequency of accidents and their seriousness continue to make it a very hazardous industry.

Although the mining industry employs only 1% of the worldwide workforce, it is the source of approximately 8% of all fatal work accidents (Jennings, 1998). In Québec, the industry accounts for approximately 0.4% of paid workers but nearly 4% of fatal accidents.[2]

Occupational injuries are costly not only for the companies concerned but also for society as a whole. In 2009, Québec employers paid some $2.3 billion in contributions to the Commission de la santé et de la sécurité du travail (CSST, 2010a). To that amount can be added other, more difficultly measured cost components, such as human costs.

This research project is part of an institutional effort to develop economic indicators in the occupational health and safety field, indicators on which the determination of research priorities, among other things, can be based. More specifically, this project aims to test, using available data, one or more methods for estimating the costs of occupational injuries and to develop a profile of these costs in the Québec mining industry. Analysis of the results and identification of the limitations of the relationship will cast light on the feasibility of developing economic indicators at the IRSST.

This report is divided into seven chapters. Following the introduction, the second chapter describes the research design. The third chapter provides a statistical overview of the Québec mining industry. The fourth chapter presents the cost estimates for occupational injuries in mines. The analysis of the results is presented in the fifth chapter. The sixth chapter focuses on the limitations encountered in the estimations. Lastly, the report ends, in chapters 7 and 8, with a conclusion and avenues for further reflection regarding the research design's applicability to other industries.

[1] In this report, the expression *occupational injuries* includes all the work accidents and occupational diseases recognized and accepted by the CSST, unless otherwise indicated. See the glossary for more details.
[2] Labour statistics estimates are based on the 2006 Census and accident statistics from the CSST.

2. RESEARCH DESIGN

2.1 Background

A review of the literature (Lebeau and Duguay, 2011) provided an overview of the current state of knowledge regarding estimation of the costs of occupational injuries. This work showed that there is no true consensus on either the cost components to be considered or how to classify them. Indeed, there are practically as many ways of classifying the costs as there are studies on the subject. In addition, some cost components are considered direct costs in some studies and indirect costs in other studies.

The literature review also shows that various economic approaches are used to estimate the costs of occupational injuries. By itself, none of these approaches can be used to obtain a complete estimate of the costs of occupational injuries. To overcome this problem, a combination of several methods (hybrid methods) appears to be the path taken in the most recent studies.

Thus this study aims to estimate the costs of occupational injuries in the Québec mining industry using the methods presented in the literature. Subsequently, we hope to be able to make recommendations to the IRSST regarding the development of economic indicators.

2.2 Statistical population studied

The population considered in this study consists of mining industry workers covered by Québec's occupational health and safety plan. Specifically, these are workers from three NAICS code categories (North American Industry Classification System – 2002). The codes are presented in table 2.1.[3]

Table 2.1: List of industries (NAICS 2002) employing the statistical population studied

NAICS	NAICS code description
2122	Metal Ore Mining
2123	Non-metallic Mineral Mining
2131	Support Activities for Mining and Oil and Gas Extraction

In addition, the occupational injuries analyzed in our studies correspond to occupational injuries and diseases that were accepted by the CSST and whose causal event occurred between January 1, 2005, and December 31, 2007.

2.3 Data sources

To achieve the objectives set out in this report, various baseline data are necessary. These are data on the number of workers, the number of accepted injuries, and the financial data related to these injuries (disbursements and contributions).

[3] See Appendix 1 for a detailed listing of these NAICS codes.

As it is impossible to obtain the exact number of mining workers covered by the Québec health and safety plan, we have used the number of paid workers and the hours worked from the 2006 Census of Population (personalized tables). Taking the monthly data from Statistics Canada's Survey of Employment, Payrolls and Hours (SEPH), we adjusted the census data to account for the monthly fluctuations of the population and hours worked during the 2005–2007 period.

The occupational injury and disbursement data come from CSST administrative records. These have an average maturity of three and a half years for injuries that occurred in 2005 and three years for injuries that occurred in 2006 and 2007.[4] In other words, the data for each of the injuries that occurred in 2005, 2006, and 2007 come from an update made on December 31, 2008, June 30, 2009, and June 30, 2010, respectively. The use of three years of injuries reduces the impact of annual fluctuations in injuries, which may be caused by exceptional events. Incidentally, the mining industry is an industry that can be subject to such events.

The disbursements are grouped into five categories:
- medical aid costs;
- rehabilitation costs;
- death benefits;
- bodily injury indemnities; and
- income replacement indemnities.

The contributions are the amounts that employers pay to cover the expenses of the occupational health and safety plan, i.e. the expenses of the CSST (CSST, 2010b). The contributions are based on the employer's insurable payroll and a contribution rate set by the CSST.[5] In this report, we will use the final contributions for all experience files associated with the NAICS codes in table 2.1 for the 2005–2007 period.[6]

To estimate some cost components, we use data from the Lavoie (2000) study, which was carried out in an underground gold mine in Québec. Its main objective was to measure the "direct" and "indirect" costs of occupational injuries in the mine over an approximately one-year period. The author measured the actual costs of occupational injuries using a questionnaire that was filled out by the employer whenever injuries occurred in the company.

Data were also obtained through meetings and discussions with Québec mining company stakeholders and by distributing a questionnaire to various members of the Québec Mining Association (AMQ). We found that the mining companies surveyed had very little information about the costs of occupational injuries not insured by the CSST. None of the consulted companies had precise data on this subject. However, the data obtained from these companies did enable us to formulate hypotheses for estimating some cost components.

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[4] This difference in maturity stems from the fact that the IRSST began to extract disbursement data only from 2009 onward. We do not feel that this will have a significant impact on the estimates obtained.

[5] The CSST classifies each employer into a unit depending on the nature of all the activities it performs. In some cases, companies that perform activities of a varied nature may be classified in several units, which may result in a given company having several different contribution rates. In addition, some companies are subject to a personalized rate, which varies according to the risk related to the company's activities.

[6] All these data come from an update performed on June 30, 2010.

Other sources were consulted in carrying out our study. These sources will be clearly identified when used in this report.

2.4 Perspective

The perspective corresponds to the level of analysis or point of view that is adopted in order to estimate the costs. All the Québec studies catalogued in the literature review (Lebeau and Duguay, 2011) estimate only the costs of occupational injuries for employers. In the scientific literature, however, the majority of studies opt instead for the societal perspective. As the IRSST works in the interest of workers as well as employers, we will examine the cost of occupational injuries from the societal perspective. It should be noted that the social perspective is not a mere tallying of the costs for workers and employers. Attention must also be paid to transfer payments, such as the compensation paid to the injured workers. From a societal perspective, these transfers only move sums of money from one agent to another (Hodgson and Meiners, 1982). Thus, the possibility of double-counting exists, which we have taken pains to avoid.

2.5 Classification of costs

The costs of occupational injuries are usually classified into three categories: direct costs, indirect costs, and human costs (also called pain and suffering costs). However, as mentioned in section 2.1, there appears to be no consensus in the literature regarding the cost components in each of the categories. That depends, among other things, on the chosen perspective. For example, in the Québec studies, direct costs are the costs insured by the CSST while indirect costs are all the other costs borne by the employer. We believe that the distinction between direct and indirect costs is not truly relevant to the societal perspective. We prefer a classification of costs based on who pays for them.

In Appendix 2, each cost component is defined and broken down by the economic agents that assume it.[7] In this report, we attempt to estimate each of the costs while identifying the share assumed by each agent (employers, workers and the community). The costs not estimated in this report are listed in section 6.1.

The costs for employers include the CSST's disbursements, although these are made by the CSST and not by employers. Because the CSST is funded entirely through contributions from Québec employers, it struck us as more appropriate to list these costs in the Employers column. In addition, in this study, "employers" are not just the employers that have experienced injuries. Some insured costs are sometimes also assumed by the other employers in the industry or by all Québec employers (e.g. the CSST's administrative costs, contribution rate exceeding a certain maximum).

The costs for workers also include the costs for the worker's family and friends. This grouping struck us as logical and is also what is done in several other studies (e.g. Access Economics, 2006; Health and Safety Executive, 1999).

[7] This table is similar to the one presented in the literature review (Lebeau and Duguay, 2011) but has been adapted for our study, i.e. it takes into account only the costs associated with injuries accepted by the CSST.

The costs for the community are the specific costs assumed by society's other economic agents and the overall costs assumed by society as a whole, including employees and workers.

2.6 Time dimension

Although an occupational injury occurs—or is reported—at a specific moment in time, it can have consequences (financial and human) for several years.[8] It is therefore necessary to choose between an analysis of costs based on either incidence or prevalence.

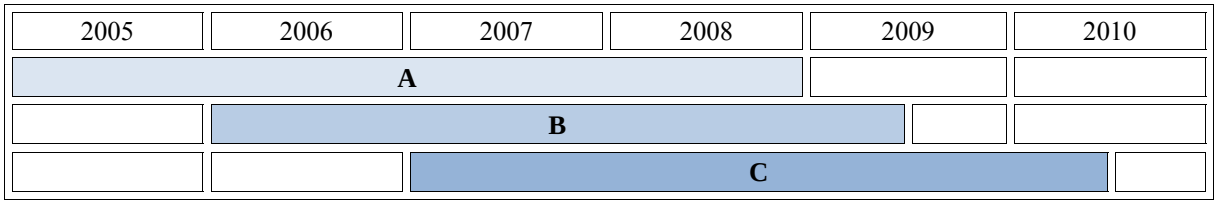
Estimating costs based on the incidence of occupational injuries corresponds to using the new injuries that occur during a specific year and estimating the total costs of these injuries, irrespective of whether they are spread over one or more years. A prevalence-based analysis focuses solely on the costs actually incurred during a specific year, regardless of when the injury happened. In this study, we use an incidence-based approach to estimating costs.

As for CSST disbursements, they are limited to the maturities presented in section 2.3. Thus, we will total all the disbursements made from the date of the incident to the date of the corresponding update. As a result, the full picture of the costs of these injuries will not be presented: some injuries may result in disbursements over a period longer than the maturity period and, consequently, those costs will not be factored in. However, for some injuries, it is possible to predict the future compensation. These are injuries for which an income replacement indemnity is paid to a worker because he[9] is unemployable due to his age.[10] In these few cases, the income indemnity paid up to age 65 can be estimated.

It should be noted that this limitation on the incidence of the costs of occupational injuries applies only to CSST disbursements. The other costs can be spread over a longer period, if necessary.

Table 2.2 makes it easier to understand the time dimension in this study. Shaded zones A, B and C correspond to the disbursement periods for injuries that occurred in 2005, 2006, and 2007 respectively and that will be used in our estimates.

Table 2.2: Costs of injuries based on incidence (disbursements only)



[8] Because occupational diseases manifest themselves only several years after exposure, it is practically impossible to obtain an event date. We are forced to use the disease report date.

[9] The systematic use of the masculine gender in this document is intended solely to facilitate reading and has no discriminatory intent.

[10] Due to the worker's age, the IRI is paid to a "…worker who is the victim of an occupational disease when 55 years of age or over or a person who suffers another employment injury when 60 years of age or over and who sustains, by reason of that disease or other injury, permanent physical or mental impairment that renders him unable to carry on his employment…" (AIAOD, s. 53).

2.7 Discount rate

Discounting is a mathematical operation that makes it possible to compare economic values over time. It consists of expressing the future value of a property or an expenditure as a current value (Montmarquette and Scott, 2007). Discounting is based on the concept of the value of time, which is reflected in our preference for immediate gratification. We prefer to have a dollar today instead of a dollar tomorrow. The same attitude, albeit inverted, applies to costs. We prefer to pay later instead of now.

Generally speaking, the discounting of a cash flow F can be expressed as:

$$F^* = \frac{F}{(1+r)^n}$$

where

- F^* is the discounted value of the cash flow;
- F it the cash flow;
- r is the discount rate;
- n is time, usually expressed as years, from the discounting date to the cash flow date.

For continuous-time models, continuous discounting is used:

$$F^* = F \cdot e^{-rn}$$

There appears to be no consensus in the literature regarding the most appropriate way to determine the discount rate. In this report, it was decided to use a real discount rate of 3%. Three arguments support this choice.

First, the discount rate is often calculated by subtracting the expected inflation rate from the rate of return for a long-term bond. The average return of Government of Canada long-term bonds for the last ten years has been around 5% and the Bank of Canada's target inflation rate is 2%. Thus, according to this formula, the discount rate would be:

$$5\% - 2\% = 3\%$$

Second, when the benefits are in the distant future, as is the case in the environment and preventive health fields and which is also the case in this report, the Treasury Board of Canada Secretariat recommends an approach that consists of estimating the social time preference rate based on the rate at which society discounts future consumption and on the forecast consumption growth rate. For Canada the social time preference rate has been evaluated at around 3% (Treasury Board of Canada Secretariat, 2007).

Lastly, in the literature review (Lebeau and Duguay, 2011) it is reported that the discount rates used in the 40 applied studies that were surveyed vary from 2.5% to 6%, with an average of 3.6% and a mean of 3.4%. A 3% rate is therefore similar to that used in other studies of the same type.

It should also be mentioned that, unless specified otherwise, the amounts appearing in this report are in 2006 Canadian dollars. The amounts measured in later years are discounted at the 3% rate and the amounts measured in earlier years are expressed in 2006 dollars using the Québec consumer price index.[11]

[11] The consumer price index data come from the Institut de la statistique du Québec.

3. QUÉBEC MINING INDUSTRY STATISTICS

3.1 Overview of the industry

Québec is mainly a producer of iron, zinc, nickel, copper, and gold. Mining sites are found throughout the province but especially in Northern Québec, Abitibi-Témiscamingue, and the North Shore. In emergency situations, when extraction or prospecting sites are in remote areas, transportation to a hospital facility can be difficult and dependant on weather conditions.[12]

During the period of the study, from 2005 to 2007, the mining industry's contribution to the Québec economy increased significantly (table 3.1).

Table 3.1: Contribution of the mining industry to the Québec economy

	2005	2006	2007
GDP of the mining industry (thousands)	$1,983,203	$2,482,935	$2,900,450
Québec GDP (thousands)	$252,709,585	$263,433,059	$278,768,371
Ratio	0.78%	0.94%	1.04%

Source: Institut de la statistique du Québec (2010a)

The average number of employees in the industry during the same period was 14,360 full-time equivalents (table 3.2).

Table 3.2: Average number of employees in the mining industry, Québec, annual average, 2005–2007

Subsector	Paid workers	FTE* workers
Metal ore mining (2122)	6,665	7,761
Non-metallic mineral mining (2123)	3,879	3,815
Support activities for mining and oil and gas extraction (2131)	2,212	2,784
Total	**12,756**	**14,360**

*FTE: Full-time equivalent

The cyclical character inherent in the mining industry generally results in large year-to-year fluctuations in the value of mineral production and the number of workers.[13]

The mining industry tends to pay wages that, on average, are higher than in most other sectors of the economy. According to a Québec government document (2009), the average annual pay in the mining industry in 2006 was about $66,500, nearly twice the average for all industries. The average annual pay of the injured mining industry workers in the CSST database is $51,301. Two aspects specific to our sample explain the difference in average pay. First, our database is not representative of all the workers in the industry, only of workers compensated for an injury accepted by the CSST. It is likely that workers in some occupations, such as engineers and

[12] Some mine sites even have a nurse and/or ambulance on site.
[13] These fluctuations are even greater when the situation is examined by subsector or ore type.

administrators, are underrepresented among the workers compensated by the CSST. In addition, pay levels recorded in the database cannot exceed $99,999. However, several mining industry workers are known to receive pay in excess of $100,000. Also, the database contains 35 injuries for which the worker's pay is $99,999, which probably means the actual pay is higher. These two factors partly explain why the average pay of our sample may be lower than the average pay for the overall industry. Table 3.3. presents the average pay of injured workers, broken down by subsector.

Table 3.3: Average annual pay of compensated mining industry workers, Québec, 2005–2007

Subsector	Average pay ($)
Mining	51,690
Asbestos	35,041
Other metal ores	60,348
Other non-metallic minerals	34,333
Iron	63,509
Support activities for mining and oil and gas extraction	49,170
Total	**51,301**

3.2 Health and safety in the mines

The mining industry is often perceived as different from other industries, as it involves very close-knit communities of workers engaged in a hard, dirty, and hazardous occupation (Jennings, 1998). The media coverage of occupational injuries in mines also contributes to the industry's poor image. Recent years have brought improvements in miners' working conditions and a reduction in compensated injuries, at least in industrialized countries. This is attributable to, among other things, the presence of an increasingly educated workforce and the increasingly automated extraction process, which makes miners' work easier and safer. Nonetheless, mines are workplaces that involve certain hazards and produce a large number of occupational injuries relative to the size of the industry's workforce.

Mines may be underground or open pit. The hazards to which workers are exposed can differ depending on the type of operation or the type of ore that is extracted. Generally speaking, health hazards in mines can be grouped into two categories: physical hazards and hazards related to airborne particulates, gases, and vapours (Weeks, 1998).

The contaminants to which miners may be exposed include airborne gases, vapours and particulate matter from diesel motor exhaust, such as carbon monoxide (CO) and nitrogen oxides (NO_x), and gases naturally present in mines, such as radon (Rn) and methane (CH_4). The impacts on health may be minimal (irritation of the nose, eyes or respiratory passages) or serious (asphyxia, lung cancer). Methane, which is found mainly in coal mines, is also responsible for many mining disasters involving explosions.[14]

[14] However, there are no coal mines in Québec.

Airborne dust, silica, and asbestos are certainly among the most documented contaminants, due to their carcinogenic properties but also to the media attention they have received. The respiratory diseases that result from exposure to these airborne particulates are often diagnosed several decades after exposure. Even today, the number of cases of silicosis and asbestosis diagnosed among older or retired workers is large.

Mines are environments with numerous physical hazards: caving, flooding, fire, explosion, noise, heat, vibration, falls, etc. Some of these hazards result in injuries, others in disease (e.g. deafness, Raynaud's disease).

3.3 Occupational injuries

Our database contains all the accepted occupational injuries for which the incident causing the injury occurred between January 1, 2005, and December 31, 2007, at the work sites of employers with NAICS codes 2122, 2123, and 2131. Table 3.4 breaks down these occupational injuries by year and by subsector. A total of 3,796 injuries were recorded during the period, giving an average of approximately 1,265 injuries a year.[15]

Table 3.4: Occupational injuries in the mining industry, Québec, 2005–2007

Subsectors	2005	2006	2007	Total
Mining (2122, 2123)	1,180	1,115	1,028	3,323
Iron	231	271	242	744
Other metal ores	518	495	442	1 455
Asbestos	55	68	60	183
Other non-metallic minerals	376	281	284	941
Support activities for mining and oil and gas extraction (2131)	128	113	232	473
Total	**1,308**	**1,228**	**1,260**	**3,796**
Deaths*	**15**	**14**	**5**	**34**

* Deaths are here accounted for in the year they occurred or the year of the compensation claim, contrary to the CSST, which records them in the year the death was accepted.

Table 3.5 presents the respective shares of accidents, occupational diseases and deaths among all recorded occupational injuries. We note, among other things, that the deaths from occupational diseases occurred entirely among asbestos industry workers.[16]

[15] The initial database contained 3,862 injuries but 66 injuries were removed because they involved disbursements only for protheses.

[16] On the other hand, a more thorough analysis shows that the average age of death of these workers was 75 years. Thus, they were probably not workers who had recently been exposed to asbestos.

Table 3.5: Profile of occupational injuries in the mining industry, Québec, total for the years 2005–2007

	Occupational injuries			Deaths*		
Subsectors	**Accidents**	**Diseases**	**Total**	**Accidents**	**Diseases**	**Total**
Mining (2122, 2123)	2,861	462	3,323	10	22	32
Iron	664	80	744	1	0	1
Other metal ores	1,229	226	1,455	2	0	2
Asbestos	92	91	183	0	22	22
Other non-metallic minerals	876	65	941	7	0	7
Support activities for mining and oil and gas extraction (2131)	442	31	473	2	0	2
Total	**3,303**	**493**	**3,796**	**12**	**22**	**34**

* Deaths are here accounted for in the year they occurred or the year of the compensation claim, contrary to the CSST, which records them in the year the death was accepted.

3.4 Financial data

The contributions that employers are required to pay to the CSST are a very large expenditure for them. The contributions are often defined by employers as being the "direct" costs of occupational injuries. Table 3.6 shows the annual insured payroll and the annual contributions paid by mining companies during the 2005–2007 period. The average annual contributions paid by mining companies during the period were $37,017,564.

Table 3.6: Insured payroll and contributions in the mining industry, Québec, 2005–2007

Annual insured payroll	$653,352,334
Annual contributions	$37,017,564
Average contribution rate (per $100)	5.67

These contributions are used to fund the occupational health and safety plan. They therefore include several cost components not directly related to the injuries but inherent in administering the plan. To make clearer what is included in these contributions, table 3.7 breaks down the average contribution rate decreed per $100 of insurable payroll in 2006 based on the contribution rate component (CSST, 2006).

Table 3.7: Average contribution rate per $100 of payroll for all CSST-insured employers, 2006

	($)	(%)
Compensation programs	1.42	61.2
For a Safe Maternity Experience program	0.15	6.5
Prevention programs	0.10	4.3
Administrative expenses and other expenses	0.35	15.1
Funding of administrative tribunals	0.05	2.2
Deficit amortization	0.25	10.8
Total	**2.32**	**100.0**

Source: CSST, 2006

The compensation programs are the disbursements related to the accepted occupational injuries. These disbursements are the sum of all the amounts paid in a claim file for a worker who has suffered an accepted occupational injury. It is the only component of table 3.7 that is available in the CSST's administrative data and the only element that we can individually link to each of the injuries.

Table 3.8 details the average disbursements paid by the CSST for the injuries that occurred during a year of the 2005–2007 period.

Table 3.8: Average disbursements in the mining industry resulting from one year of injuries, Québec, 2005–2007

	Average annual disbursement
Medical aid costs	$2,639,852
Rehabilitation costs	$497,877
Death benefits	$1,081,054
Bodily injury indemnities	$1,931,394
Income replacement indemnities (IRI)	$10,236,624
Total disbursements	**$16,393,690**

We note that the occupational injuries during one year in the mining industry resulted in an average disbursement by the CSST of $16,393,690, which corresponds to approximately 44% of the contributions paid. Some 1.5% of the accepted injuries did not involve a disbursement. Among those that involved a disbursement, the average disbursement was $13,154 ($10,071 for work accidents and $33,882 for occupational diseases).

The other components of table 3.7 cannot be obtained for each injury but can be estimated based on tables 3.6 and 3.7.[17]

[17] It should be noted that the expenditures for prevention programs include prevention services and follow-up by the Québec health and social services department's occupational health teams, the IRSST's grant, grants from joint sector-based associations, grants from union and employer associations, and other traning and information grants (CSST, 2010b).

4. COSTS OF OCCUPATIONAL INJURIES IN MINES

As presented in this report, the costs of occupational injuries are not classified as direct or indirect costs. Instead, they are presented successively, specifying the share assumed by each of the economic agents concerned. It should also be noted that they are annual average costs expressed in 2006 dollars.

To make this section less cumbersome to read, the cost components not estimated in this report but included in the table in appendix 2 are listed in section 6.1.

4.1 Medical costs

Medical costs are all the expenditures made to treat and rehabilitate an injured or sick worker. Besides the amounts spent on medical personnel, medical equipment, and medications, transportation expenses and administrative expenses (hospitals) are often included under this heading.

Medical costs for employers

The main medical costs incurred to treat and rehabilitate workers suffering from a work accident or occupational disease are borne by employers through their CSST contributions. These are mainly medical aid costs and rehabilitation costs.

Medical aid costs comprise several elements. Generally speaking and with reference specifically to section 189 of the *Act respecting industrial accidents and occupational diseases* (AIAOD), medical aid consists of the following:

1. the services of health professionals;
2. the care or treatment provided by a health care institution;
3. medicines and other pharmaceutical products;
4. prostheses, orthoses, tissues, etc.;
5. other care, treatment, or technical aid determined by regulation by the Commission (chiropractic, psychology, acupuncture, etc.).

In the CSST's administrative records, medical aid costs also include other elements, such as transportation and lodging expenses, administrative expenses, and expenses for property damage caused to workers during the accident. In these same administrative records, we note that rehabilitation costs include household production costs (home-care service, babysitting, house cleaning, etc.).

The medical costs assumed by the employers are obtained by adding together the medical aid costs and the rehabilitation costs in table 3.8. However, as the household production costs are estimated in another section of this report (section 4.5.3) and as it was possible to separate them from the rehabilitation costs, we have subtracted those amounts. Thus, the compensated medical expenses total $2,984,593.

Other costs associated with the first aid provided to injured workers are assumed by employers. The first aid supplies and equipment used at the time of the accident and the time devoted by a nurse on the mine's payroll are the main costs. As these costs are not insured by the CSST, they have to be estimated.

Lavoie (2000) figures the average costs per injury for the first aid provided in response to occupational injuries in a Québec gold mine to be $10.44 (in 2000 Canadian dollars). In 2006 dollars, the costs totalled $11.85. Applying these costs to all work accidents gives us annual costs of $13,047.

Most mining companies have at least one on-staff nurse at the mine site. The nurses do not usually devote all their time to occupational injuries. Based on questionnaires filled out by stakeholders in the industry, we were able to estimate both the number of nurses employed at Québec mines and the percentage of their workload devoted to occupational injuries. On average, there is a single nurse per mine, who devotes 34.4% of his workload to occupational injuries. Taking an average salary of $58,681 and assuming that nurses are found only at Québec's active mines (26 in 2011 according to the Québec department of natural resources and wildlife), the cost of the nursing personnel at Québec mines is estimated at $525,453.[18]

Table 4.1 presents all the medical costs that were estimated.

Table 4.1: Medical costs associated with occupational injuries during one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Compensated medical expenses	$2,984,593	-	-	$2,984,593
First aid	$13,047	-	-	$13,047
Nurses	$525,453	-	-	$525,453
Total	**$3,523,093**	**-**	**-**	**$3,523,093**

4.2 Transportation/Emergency

Transportation expenses for employers

Some injuries require that the injured workers be taken to a hospital centre. The transportation may be due to an emergency or in order to obtain a medical opinion. These costs are usually borne by the employer. To estimate the costs, we used the average transportation cost for all injuries obtained by Lavoie (2000). In 2006 dollars, that is $177.03. Applying this amount to all occupational injuries, we obtain an estimated cost of $194,910 for one year of injuries (table 4.2). When the extraction or prospecting site is in a remote area, which was not the case for the mine in the Lavoie (2000) study, transportation to a hospital centre may require the use of an emergency air service (e.g. Medivac). This can generate transportation costs much higher than those used.

[18] The average salary of a nurse working in the private sector in Québec is used. This datum comes from a report published by the Institut de la statistique du Québec and titled *Résultats de l'Enquête sur la rémunération globale au Québec – Collecte 2007*. The salary is expressed in 2006 dollars using the Québec consumer price index.

Table 4.2: Transportation and emergency services generated by the occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Transportation of injured workers	**$194,910**	-	-	**$194,910**

4.3 Funeral costs

Some work accidents and occupational diseases may result in death. These deaths entail funeral costs.

Funeral costs for employers

Part of the funeral costs paid by the victims' families may be reimbursed, up to a maximum amount, through a death benefit paid to the individual who paid them. The monies are used to pay for funeral costs and transportation of the corpse. The CSST's administrative records show that these payments totalled $25,077 annually over the study period.

As these amounts are listed as death benefits in table 3.8, care must be taken to avoid counting them twice in subsequent estimations.

Funeral costs for workers

Based on our examination of a large number of websites dealing with the subject, we estimate the average funeral costs to be approximately $7,500. These costs are borne by the deceased's family but may be partially compensated by the CSST. The amounts of the funeral costs assumed by the victims' families are estimated as the difference between $7,500 and the funeral costs reimbursed by the CSST.

The deaths that occurred in the mines during one year resulted in funeral costs estimated at $85,000 (table 4.3). Of this amount, $25,077 is paid by employers in the form of benefits to families and $28,333 by the community in the form of death benefits from the Régie des rentes du Québec (RRQ). The remainder, $31,590, is assumed by the deceased workers' families.

Funeral costs for the community

As mentioned earlier, the funeral costs assumed by the community are limited to the death benefits granted by the RRQ to the person who paid the funeral costs. The death benefit is a lump sum payment of $2,500 and is granted if the deceased made a sufficiently large contribution to the RRQ. We assume that is the case for all the deaths in our sample.

Table 4.3: Funeral costs associated with occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Funeral costs	**$25,077**	**$31,590**	**$28,333**	**$85,000**

4.4 Salary costs

First, it is important to clearly define what we mean by salary costs. In the literature, the terms "productivity losses" and "salary costs" are often used to identify very similar cost components. In this report, salary costs are defined as being unworked (or non-productive) hours that employers nonetheless pay in the form of wages and employee benefits.

The day of the accident, the employer is required to pay full wages for the day and the corresponding employee benefits to an employee who suffers an injury on the job and is unable to work the rest of the day. However, it is impossible for us to know at what point in the day the injury occurred. We assume that, on average, at the time of the injury, a half-day of work remained to be done. Thus, a salary cost equal to a half-day's wages plus the employee benefits has been assigned to all work accidents.[19] These costs are estimated to be $148,169 a year.

Workplace accidents can also have repercussions on the work of other, uninjured workers. These workers may be ones who assisted the accident victim, supervisors, or others whose work is related to that of the injured employee. This type of cost can be more difficult to measure and can depend on the severity of the injury and on the company's production structure. We refer to the Lavoie (2000) study, which obtains average costs of $152.93 (in 2000 Canadian dollars) for the time lost by the other workers and the supervisors. That corresponds to $173.52 in 2006 Canadian dollars, the amount we assigned to each work accident.[20] These costs total $191,046 a year.

In our discussions with various mining companies, it emerged that the mining industry is inclined to use temporary assignment whenever possible.[21] Indeed, in the Lavoie (2000) study, the author notes that 92.3% of accidents resulted in a temporary assignment in the mining company being studied. Although the use of temporary assignments allows compensation costs to be reduced, it is costly in terms of waste pay. However, it is very difficult to accurately assess the cost of this waste pay. The consulted mining companies do not know how much it may cost them. Nonetheless, some of them told us that the costs must be very high.

To calculate the cost of temporary assignment, two statistics are required: the number of cases of temporary assignment and the average cost of temporary assignments. To obtain the number of cases, data from the Association paritaire pour la santé et sécurité du travail du secteur minier (APSM) were used. The APSM records about 485 temporary assignments a year. These data probably underestimate the actual number of temporary assignments. First, because the APSM is not the joint sector-based association for all the companies associated with the NAICS codes listed in appendix 1, the data provided to us by the APSM do not cover our entire sample. Moreover, not every mining company provides data to the APSM (the data are provided to the APSM on a voluntary basis). Lastly, the APSM data concern only work accidents. Thus,

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[19] Employee benefits increase workers' compensation by 35% (see section 4.5.2 for more details).

[20] Employee benefits are included in the Lavoie (2000) estimates.

[21] Temporary assignment allows the employer to assign a job to an employee even if he hasn't fully recovered from the injury, while waiting for the employee to become able to return to his job or to perform a suitable job (CSST, 2002). When a worker is on temporary assignment, he is paid his full salary even though he is usually not as productive as he was before the injury. The worker is often assigned to training or to tasks that take into account his reduced ability to work.

temporary assignments resulting from occupational diseases are unaccounted for. However, the data do include the temporary assignments for injuries that were not declared to the CSST.

Once again, we refer to the Lavoie (2000) study in order to estimate the average cost of temporary assignments in the mining industry. One of the important contributions of the Lavoie study was the development of a grid that shows the waste share of the pay ascribable to each temporary assignment task in the mine.[22] This allows the author to measure the waste pay of each worker on temporary assignment. The author obtains an average cost of $4,214 (in 2000 Canadian dollars) per accident with a temporary assignment. That corresponds to $4,781 per temporary assignment in 2006 dollars. Multiplying this amount by the number of temporary assignments in the period gives an annual cost for temporary assignments of $2,320,590.

In some cases, employers may assume other salary costs. More specifically, with the goal of returning productivity to the level it was at prior to the accident, the co-workers may do overtime. This overtime is also a salary cost for the employer. To estimate the portion of the workload compensated for by overtime, we submitted questions to a number of mining companies. The companies use multiple strategies to make up the workload of injured workers, including distributing the work among the company's other workers, overtime, the hiring of temporary resources, the hiring of permanent resources, and not performing the work.

Before making the estimates, several hypotheses based on comments obtained from the various stakeholders were developed. In this report, we have used the assumption that, during the first two months of absence, half of the workload will be made up by overtime and the other half will be shared among the other workers at no additional cost to the employer. Accordingly, for the first two months of absence and using an overtime bonus of 50%, the cost of overtime is calculated as follows:

$$\text{Cost of overtime} = \frac{1}{2} \times \left(\frac{\text{compensated days (maximum of 60)}}{365} \times \text{annual salary} \right) \times 50\,\%$$

For any absence longer than two months, the injured worker will be replaced by a contract worker at no additional salary cost for the employer. Only in rare cases will a permanent regular worker be hired (see section 4.6). Overtime has also been assigned in cases of death due to a work accident. In such cases, the overtime cost is calculated using the same formula but assigning 60 days of compensation.

Based on these assumptions, mining companies would have spent $719,651 annually in overtime due to occupational injuries.

Table 4.4 presents the various salary costs that have been estimated in this section.

[22] This grid was prepared with the assistance of the OHS managers and the heads of the departments concerned with the temporary assignments.

Table 4.4: Salary costs associated with occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Waste pay of the injured worker on the day of the accident	$148,169	-	-	$148,169
Waste pay of the other employees	$191,046	-	-	$191,046
Waste pay of the accident victim on temporary assignment	$2,320,590	-	-	$2,320,590
Overtime	$719,651	-	-	$719,651
Total	**$3,379,455**	**-**	**-**	**$3,379,455**

4.5 Productivity losses

In this report, the productivity lost due to occupational injuries corresponds to the value of the paid and unpaid work that is no longer performed by the injured worker. In the following sections, we describe how it was possible to arrive at these estimates.

4.5.1 Lost wages

The estimation of productivity losses with respect to paid work is based on the principles of the human capital method, i.e. that an individual's contribution to society can be measured by his contribution to the gross domestic product (GDP).[23] In other words, the decrease in productivity corresponds to the decrease in GDP. From this standpoint, it is society's capacity for producing goods and services that is of primary interest. In addition, the worker's contribution to GDP can be estimated as his gross earnings (before income tax), which corresponds to the marginal productivity of his work. Therefore, we multiply the worker's gross pay by his time away from work.

To produce these estimates, the injuries were separated into two categories: non-fatal injuries and fatal injuries. For the non-fatal injuries, the worker's daily gross pay was simply multiplied by the number of compensated days.

For the fatal injuries, the human capital method was used. This method accounts for the future gross earnings from the year of death to the expected year of retirement. Inspired by Rice et al. (1989), the overall model is as follows:

$$PV = \sum_{n=y}^{60} P_{s,y,n} \times S \times \left(\frac{1+g}{1+r}\right)^{n-y} \quad (1)$$

where

- PV is the present value of future earnings;
- $P_{s,y,n}$ is the probability that a person of sex s and of age y will survive to age n;
- S is the worker's annual pay before the injury;

[23] Statistics Canada defines GDP as an aggregate measure of economic activity that corresponds to the unduplicated value of the goods and services produced in the economic territory of a country or region during a given period.

- *g* is the rate of increase of labour productivity;
- *r* is the real discount rate.

The retirement age used was 60 years. This figure comes from the Institut de la statistique du Québec (2009), which estimates the average retirement age of Québec employees in 2008 as 60.2 years old.[24] The probability of survival comes from the mortality tables published by Statistics Canada (2006). The rate of wage growth attributable to productivity was set at 1%.[25] Lastly, the discount rate used was 3% (see section 2.7).

The total lost wages resulting from injured or deceased workers' withdrawal from the labour market amount to $24,003,067. This loss may be defined as equivalent to the lost production capacity for society. As will be discussed in the remainder of this section, each of the three main economic agents identified in this report assumes part of these costs.

Lost wages assumed by employers

The lost wages resulting from the injured employee's withdrawal from the labour market are partly covered by employers through income replacement indemnities (IRI) and death benefits paid to the employee and his family. The amount of the income replacement indemnities and death benefits paid by the mining companies during the period under study totalled $10,236,624 and $1,055,977 respectively.[26] To this can be added the income replacement indemnities anticipated up to age 65 for injuries for which an IRI has been paid to an unemployable worker or to a worker due to his age (see section 2.6). These indemnities amount to $3,563,342. The total of the income replacement indemnities and death benefits assumed by the employers is thus $14,855,943.

Lost wages assumed by workers

For the worker, the lost wages correspond to the difference between his pay before and after the injury. First, during the benefit period, these lost wages are measured as the difference between the income replacement indemnity that the worker received and his take-home pay. Then, once the injury is "repaired", the worker may change career paths, which can have an impact on his pay. Lastly, when a work accident results in the death of a worker, the deceased's family has to absorb a drop in family income.

At the CSST, the income replacement indemnity corresponds to 90% of net employment income up to the maximum annual insurable earnings.[27] During the indemnization period, the workers

[24] This is the most recent datum published by the ISQ when this report was written. We preferred not to make any assumptions about changes in the retirement age.

[25] According to a document published by the Institut de la statistique du Québec (ISQ, 2010b), labour productivity grew at an annual average rate of 0.9% in Québec over the 2000–2009 period. In addition, the productivity growth rate usually assigned in the literature is 1%.

[26] To avoid double-counting, the compensated funeral expenses have been subtracted from the death benefits.

[27] The maximum insurable gross earnings for 2005, 2006, and 2007 are $56,000, $57,000, and $59,000 respectively.

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therefore have to absorb lost wages equivalent to 10% of their net income. This 10% of net income can be estimated using a simple calculation:

$$10\%\ \text{of net income} = \frac{\text{IRI}}{90\%} \times 10\% \qquad (2)$$

These costs amount to $1,533,330. However, they correspond to only a part of the lost wages assumed by workers during the indemnity period. Actually, in the mines there are many workers with earnings higher than the maximum insurable earnings. For these workers, the lost wages can be much greater. To estimate these costs, we first measured the amount of gross income that exceeded the insurable maximum.[28] Then, assuming an income tax rate of 50%, the loss of net earnings corresponds to 50% of the overage. These losses total $473,197. Thus, the total lost wages for workers during the indemnity period are $2,006,527.

When a worker dies, the family's income decreases by an amount equivalent to the worker's total net income up to the expected age of retirement. To estimate this loss, we used equation (1) above. However, to measure the loss only for the deceased's family and not for society as a whole requires using the net earnings, which are not included in the CSST database. To obtain the net earnings, we converted the gross earnings using the Table des indemnités de remplacement du revenu [income replacement indemnity table] published by the CSST in 2006. In making the conversions, we assumed that the deceased workers were all bachelors without dependants.[29] The table allows gross earnings to be estimated up to the insurable maximum for the year 2006 ($57,000). For gross earnings above the insurable maximum, we applied an income tax rate of 50%. The lost wages resulting from the deaths of mining workers and assumed by the victims' families are estimated at $1,331,429. However, from that amount must be subtracted the death benefits received from the CSST. Thus, the lost wages assumed by the victims' families total $275,452.[30]

The total lost wages assumed by workers and their families are therefore $2,281,979.

Lost wages assumed by the community

The loss of wages can also have an impact on the community. First, there is a decrease in government tax revenues. For example, the income replacement indemnities received by the worker in lieu of lost wages are not taxable. Thus, lost wages entail a loss of income tax (Gosselin, 2004). In addition, the worker receiving the income replacement indemnity is not required to contribute to employment insurance, the Québec parental insurance plan, or the Québec pension plan. Not contributing does not penalize the worker, who retains his rights with respect to these plans and programs. Thus, it is everyone who contributes to these plans and programs who has to absorb the related costs.

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[28] We have used the average maximum insurable earnings for the period, i.e. $57,333.33.

[29] As the database used contains no information of a personal nature (marital status, number of dependants, etc.), these assumptions had to be made. They may have entailed an underestimation of the net earnings and thus of the losses of pay for the victims' families.

[30] It should be noted that this type of cost applies only to deaths of workers age 60 or under.

In this report, the lost wages assumed by the community are estimated by subtracting from the gross earnings of the workers on leave the estimated net earnings of the same workers. The estimated amounts thus include the unpaid income taxes and the contributions to the various plans and programs mentioned above.

First, there is a loss for the community during the indemnity period. This can be determined by measuring the loss of gross earnings during the indemnity period and subtracting the IRI amounts paid by the employers during the period and the loss of net earnings assumed by the workers. This loss corresponds to $6,295,957.

There is also a loss for the community following the death of workers. To measure this loss, equation (1) was applied using the gross earnings; from this was subtracted $1,331,429, i.e. the lost wages, before compensation, for the deceased's family. The lost wages due to death entail a cost for the community of $569,188.

The total loss of income taxes and other revenues that the community has to assume is thus estimated at $6,865,145.

4.5.2 Employee benefits

Hensler et al. (1991) maintain that an individual's pay does not correspond entirely to the pay he obtains from work. Some workers receive employee benefits, which are paid by the employer and which may be considered as making up part of the labour cost. Employers who pay for these employee benefits expect to recover these expenditures through their employees' productivity. Thus, to the pay in equation (1), several authors add the value of the employee benefits that are usually paid to the worker (prior to the accident).[31] To calculate the value of these employee benefits, a percentage of the pay is normally used. For example, Miller and Galbraith (1995) use 20% and Leigh et al. (2000) use 23.3%.

For this report, three sources were consulted before determining the percentage by which employee benefits increase base pay. First, a Statistics Canada document (2003) estimates that the mandatory employee benefits (Employment Insurance, Québec Pension Plan, etc.) and discretionary employee benefits (pension plans, insurance plans, etc.) increase workers' compensation by 36%, on average, in all industries. The same document mentions that the mandatory employee benefits increase compensation by about 12% and discretionary social benefits by about 24%. However, CSST contributions are considered mandatory employee benefits. Second, in the Lavoie (2000) study, the author estimates that employee benefits amount to 30% of the workers' pay at the Québec mining company studied. Lastly, a mining company that we consulted estimated that the value of employee benefits corresponds to about 34% to 36% of the mining workers' pay, excluding CSST contributions.

In this report, we estimate that, on average, employee benefits increase mining workers' base pay by 35%, specifically 10% for mandatory employee benefits (excluding CSST contributions,

[31] It should be specified that these do not include the employee benefits already included in the pay, such as vacations, sick leave, and bonuses. Generally speaking, they are pension plans and group insurance plans.

which are accounted for in other sections of the report) and 25% for discretionary employee benefits.

Equation (1) can thus be modified to take these employee benefits into account:

$$PV = \sum_{n=y}^{60} P_{y,s,n} \times (S \times (1 + EB)) \times \left(\frac{1+g}{1+r} \right)^{n-y} \quad (3)$$

By adding 35% in employee benefits (*EB*) for each injured worker, we obtain a loss of production capacity of $32,404,141, of which $8,401,073 is attributable solely to the value of employee benefits.

The value of these employee benefits is not a loss borne exclusively by the employers: the workers and the community also bear a not insignificant share.

Employee benefit costs for employers

When a worker is off work due to an occupational injury, the employer continues to pay for some employee benefits. Using Revenu Québec's annual *Guide for Employers: Source Deductions and Contributions*, it is possible to determine the amounts that employers are required to continue paying after an occupational injury. Two pieces of information should be kept in mind for the purposes of this study.

First, on the day of the accident the employer is required to pay all the amounts (mandatory and discretionary employee benefits) that are usually paid to the employee. The value of these employee benefits is already included in the estimate of the lost wages on the day of the accident (section 4.4). These employee benefits are therefore not included in this section.

Second, when the worker receives an income replacement indemnity, the employer does not have to pay for the mandatory employee benefits. These amounts are borne by the various plans, i.e. by other contributors. However, we assume that most of the discretionary employee benefits continue to be paid during the indemnity period.[32] Applying a rate of 25%, the employee benefit costs paid by the employers for a worker off work due to an occupational injury amount to $4,126,258.[33]

Employee benefit costs for employees

Workers are not penalized during the indemnity period. However, in the event of death, none of the employee benefits, which increase a worker's compensation by an average 35%, are received by the workers or their families. It is therefore a cost borne by the employees and their families. This loss is estimated at $665,216.

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[32] Depending on the case, the employer may stop contributing to some plans (e.g. the pension plan). In such cases, part of the discretionary employee benefits is absorbed by the plan concerned.

[33] Seeing as how this is a kind of compensation paid during the worker's absence, these costs could have been defined as salary costs.

In addition, with respect to the injuries for which we have projected income replacement indemnities, i.e. persons who have become unemployable or those who receive an IRI due to their age (see section 2.6), we assume there is a break in the employment relationship between the worker and the employer. Thus, the employer no longer pays for employee benefits. The workers bear the loss of the discretionary employee benefits and the community bears the mandatory employee benefits, as the workers are not penalized. The value of these discretionary employee benefits is estimated at $1,399,354.

All told, the workers lose the equivalent of $2,064,570 in employee benefits.

Employee benefit costs for the community

During the period when the workers receive an income replacement indemnity, the employers do not have to pay for the various mandatory employee benefits. The workers are not penalized because these costs are absorbed by the community (the other contributors). Evaluated at 10% of pay, these costs assumed by the community are estimated to be $2,210,245.

4.5.3 Unpaid household work

Occupational injuries can also have an impact on workers by affecting their ability to perform household work. Hawrylshyn (1978) defines household work as "those economic services produced in the household and outside the market, but which could be produced by a third person hired on the market without changing their utility to the members of the household."

In a more recent Statistics Canada (2010) document, unpaid household work is defined in greater detail as follows:

> Unpaid housework refers to activity in which the person provided unpaid service such as domestic work, yard work or home maintenance for his or her household, for other family members outside the household or for friends or neighbours. It excludes volunteer services provided through a non-profit or religious organization, charity or community group. Unpaid housework includes, for example: preparing meals and associated cleanup; washing the car; doing laundry, ironing, folding and mending; gardening and cutting the grass; shopping and household planning as well as associated travel. (Statistics Canada, 2010)

To estimate the value of this time devoted to household work, Chandler (1994) suggests two approaches: the opportunity cost approach and the replacement cost approach. In the first, the value of one hour of household work is based on the hourly earnings, before income tax, of the individual concerned. The second estimates what performing the household work would cost on the labour market.[34]

[34] For a more detailed definition of the opportunity cost approach and the replacement cost approach, see Lebeau and Duguay (2011).

In this report, we use the replacement cost approach. The data come from Hamdad (2003), who uses data from the 1998 General Social Survey (GSS). We took the average annual value of household work in Canada according to gender. We then expressed the amounts in 2006 dollars using the Québec consumer price index. In this report, the value of the unpaid work in 2006 is estimated at $17,823 for women and $10,999 for men.

Household work costs for employers

The CSST assumes part of the costs associated with the inability to perform household work. Some disbursements are associated with home maintenance costs, daycare costs, home support or adaptation costs, and main vehicle costs. On average, these disbursements are on the order of $153,136 for the period studied.

Household work costs for employees

In the literature, the value of household work is usually inserted into equation (1) to obtain a complete estimate of productivity losses using a single formula. However, this assumes that the individuals perform the household work only during their working years. In this report, the loss of household work is estimated until the worker's expected age at death. The cost of household work not performed due to the workers' death is calculated as follows:

$$PV_{HW} = \sum_{n=y}^{y+e_y} \frac{HW_s}{(1+r)^{n-y}} \tag{4}$$

where

- PV_{HW} is the current value of the unperformed household work;
- HW_s is the annual value of household work for an individual of sex *s*;
- *y* corresponds to the worker's age at death;
- e_y is the average number of years remaining in the worker's life;
- *r* is the real discount rate.

The age-based life expectancy is obtained through the mortality tables published by Statistics Canada (2006).

The cost of non-productive household work due to death is estimated at $1,536,395.

For injuries not resulting in death, some authors simply multiply the number of compensated days by the daily value of the household work, the assumption being that a worker who is unable to perform his paid work is also unable to perform unpaid household work. This assumption is generally untenable.

Occupational injuries with compensated days probably have a significant impact on the worker's ability to perform household work at home. However, it is likely that some less limiting injuries allow some workers to perform some household tasks. Based on several studies, which are themselves based on survey results, we assume that 90% of compensated days are also non-

productive household work days.[35] Accordingly, the household work cost for occupational injuries with compensated days is estimated at $3,088,167.

Subtracting the costs borne by the employers through their CSST contributions, the total cost of non-productive household work for the workers and their families is $4,471,426.

Table 4.5 presents a summary of the costs of productivity losses.

Table 4.5: Productivity losses resulting from occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Lost wages				
Income replacement (IRI + death benefits)	$14,855,943	-	-	$14,855,943
Lower earnings (net of compensation)	-	$2,281,979	-	$2,281,979
Income tax and other deductions	-	-	$6,865,145	$6,865,145
Employee benefits	$4,126,258	$2,064,570	$2,210,245	$8,401,073
Household work				
Compensation for household work	$153,136	-	-	$153,136
Household work net of compensation	-	$4,471,426	-	$4,471,426
Total	**$19,135,337**	**$8,817,975**	**$9,075,390**	**$37,028,703**

4.6 Administrative costs

The administrative costs arising from a work accident or an occupational disease may be numerous. These costs are borne entirely by the employers concerned.

It is difficult to accurately measure the scale of these costs because they are not usually included in corporate financial statements. The following administrative costs are estimated in this report:

- Administrative costs of the compensation board;
- Administrative costs related to accident files;
- Employee turnover costs (recruiting and training a new employee).

The CSST's administrative costs are included in the contributions paid by employers. To isolate the administrative costs from the total contributions, a percentage approximately corresponding to the administrative costs' share of the total contributions (table 3.7) can be applied. Using a rate of $0.35 per $100 of insurable payroll, we estimate that Québec mining companies' contribution to paying the CSST's administrative costs averages $2,286,733 a year. Because some administrative costs may not be related to occupational injuries (e.g. rate setting), the estimated amount probably overestimates the administrative costs related solely to occupational injuries.

[35] See Miller and Galbraith (1995), Corso et al. (2006), Waehrer et al. (2007), and Lawrence et al. (2009).

The costs related to administering accident files by employers following an accident are difficult to assess without carrying out a survey in the companies. Were that to be done, it would suffice to multiply the salary of the person in charge of the records by the time devoted to his task. Otherwise, an estimate has to be developed using data from other studies. For example, Lavoie (2000) obtains an average cost of $452.26 (in 2000 Canadian dollars) for the time devoted to administering of accident files at a Québec gold mine. However, it is impossible to know whether that amount is representative of the industry. As it is a recent estimate in the same industry, we have used the average cost obtained by Lavoie and adjusted to 2006 dollars, i.e. $513.16. For the entire industry, these costs thus total $649,318.

Recruitment and training costs are also very difficult to estimate. The main difficulty lies in determining which injuries have resulted in the hiring of a replacement. In our discussions with mining companies, we were told that recruitment following an occupational injury for the purpose of meeting work requirements is a very rarely used option. Basically, no regular permanent position to replace an injured worker will be created unless it is clear that the worker will never return to work due to his injury.

To identify these rare situations where injuries may have resulted in a recruitment, several criteria were developed. These criteria are:

- Death due to a work accident;
- Death due to an occupation disease in workers age 60 and under;
- Injuries with an IRI paid to an unemployable worker;
- Injuries with an IRI paid due to an occupied suitable employment;[36]
- Injuries with an IRI paid due to an unavailable suitable employment;
- Injuries with an IRI paid due to an unoccupied suitable employment;
- Injuries with an IRI paid to a worker who is suffering from an occupational disease when he is at least 55 years of age or who is the victim of an accident when he is at least 60 years of age and who suffers, due to this disease or other injury, a permanent impairment of his physical or psychological integrity that makes him unable to perform his work.

Under these criteria, occupational injuries in mines would have resulted in around 73 instances of recruitment for regular positions.

Assigning an average cost to recruitment and training in the mining industry is no easy task. This is all the more true for some mines located in remote areas, such as Northern Québec, where recruitment costs can be very high due to, among other things, the travel expenses related to the interviews, which are usually paid for by the employer.[37]

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[36] When an income replacement indemnity is paid due to an occupied suitable employment, this means that the worker holds a position different from the one he held before the injury, at either a new employer or the same employer. When the worker's new pay is less than his former pay, the CSST compensates him for the difference. For the employer, this means having to replace the injured worker in his former position.

[37] It should be noted that some mines in remote areas are required to comply with agreements covering the hiring of Aboriginal workers. The training necessary for these workers is usually longer and more costly.

The literature often refers to employee turnover costs. This usually includes other cost components besides recruitment and training, such as the productivity losses of the replacement worker and other co-workers. To estimate the employee turnover cost, a percentage of the annual pay of the worker to be replaced is often used. Based on a study of nine Australian mines, Beach et al. (2003) estimated the employee turnover costs as a percentage of annual pay adjusted according to the type of job (table 4.6)

Table 4.6: Employee turnover costs as a percentage of annual pay

Type of position	Percentage of annual pay (%)
Operations	30
Processing and other	50
Supervisors	100
Management and mine professionals	150

Source: Beach et al. (2003)

Because many occupational injuries occurring during mining operations and in order not to overestimate the costs, we assigned an employee turnover cost of 30%. These costs total $1,182,986 for our sample or $16,205 per recruitment.[38]

Table 4.7 presents a summary of the administrative costs.

Table 4.7: Administrative costs associated with occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Administrative costs of the compensation agency	$2,286,733	-	-	$2,286,733
Administrative costs related to the accident files	$649,318	-	-	$649,318
Employee turnover costs (recruitment, training, etc.)	$1,182,986	-	-	$1,182,986
Total	**$4,119,038**	**-**	**-**	**$4,119,038**

4.7 Legal costs

Occupational injuries can give rise to legal costs in several ways. First, the decisions made by the CSST may be contested by workers or employers. Second, the CSST may take legal action against employers over the application of laws and regulations. Lastly, an employer may be sued on third-party liability grounds or under the Criminal Code.

Accidents that result in an investigation, complaint or lawsuit can generate very high costs. Even if injuries are only partly responsible for these costs, in the literature an average legal cost is usually assigned to all injuries. Brody et al. (1990), using a survey in several companies, obtain an average legal cost of $68.17 (in 1990 Canadian dollars) and average fees of $956.69 per injury

[38] By way of comparison, the U.S. Department of Labor's Bureau of Labor Statistics estimates the average cost of replacing a worker in a private sector company as US$13,996 (O'Connell and Kung, 2007).

that generates legal fees.[39] However, these results are not representative of the mining industry alone. Moreover, it should be noted that since the Brody et al. (1990) study was published, the federal government has amended the Criminal Code to facilitate legal action against negligent companies. Thus, since March 31, 2004, companies have been required to satisfy the principle of due diligence, which means they must be able to demonstrate that they have not been negligent.[40]

Using questionnaires distributed and completed by Québec mining industry stakeholders and members of the Québec Mining Association, it was possible to obtain the average legal costs paid annually by some of these companies. Although it is impossible to confirm that the consulted companies are representative of the entire industry, it is probably a more appropriate source than the Brody et al. (1990) study. An average legal cost of $95.84 per worker was used and applied to the entire industry. Thus, the total annual legal costs for the overall industry are $1,376,334.[41]

The employers also pay for the funding of the Commission des lésions professionnelles (CLP), which is responsible for hearing and deciding on challenges to CSST decisions. Borne by the employers through their contributions, these costs can be estimated using table 3.7. Applying a rate of $0.05 per $100 of insurable payroll, we estimate that Québec mining companies contribute a total of $326,676 a year to funding the CLP. Because some challenges may not be related to occupational injuries (e.g. challenges relating to rate setting), the estimated amount probably overestimates the "real" cost of injuries at the CLP. Nonetheless, we feel that the majority of contestations are of decisions rendered after occupational injuries and that the overestimation is probably quite low.

Table 4.8 presents a summary of these results.

Table 4.8: Legal costs associated with occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Legal costs	$1,376,334	-	-	$1,376,334
Commission des lésions professionnelles (CLP)	$326,676	-	-	$326,676
Total	**$1,703,010**	**-**	**-**	**$1,703,010**

4.8 Human costs

Human costs are also called pain and suffering costs or intangible costs by some authors. Although these costs are difficult to measure and easy to challenge, they are nonetheless very real. In fact, the CSST compensates the workers concerned for this type of cost (bodily injury indemnities).

[39] In the Brody et al. (1990) study, the legal costs were obtained by adding together the costs for lawsuits and for medical disputes.

[40] In other words, the principle of due diligence means that employers must take all reasonable precautions in certain circumstances to prevent disease or accidents at the workplace.

[41] Employers who replied to the questionnaire may have included indemnities paid to workers in their legal fees. If so, these indemnities do not correspond to a cost at the societal level but rather to a transfer payment.

Human costs essentially relate to the value of the change in the quality of life of the worker and those in his circle (family, friends, co-workers and other members of the community) as well as to the duration of such changes and, in cases of death, to the potential lost years of life. A definition of these costs, found in a study by professor David Weil, explains the problem:

> Quality of life is a difficult concept to define, but here refers to diminishment of health, psychological well-being, and family and social interactions arising from the injury. In some senses quality of life losses overlap with changes in household and other non-work time allocation described above. But they also go beyond this realm to include the burden imposed on the disabled by feelings of depression, anger, and pain arising from limitations in all realms of activity. (Weil, 2001)

In this report, the human costs associated with occupational injuries are estimated using a health status index in combination with the willingness-to-pay method.

Health status index

A health status index makes it possible to assess different health states using a single unit of measure (Goodchild et al., 2002). The two most popular measures for performing this task are QALY and DALY. These two measures take into consideration both the life expectancy of individuals and their quality of life.

Under the QALY (quality-adjusted life year) approach, each of the remaining years of life (T) is weighted according to an index (q) that corresponds to the individual's health status.

$$Q = \sum_{i=1}^{N} q_i T_i \tag{5}$$

Equation (5) divides the individual's life into N periods, each with a different health status. A QALY, which corresponds to a full year with an optimal health status, is the unit of the result obtained using this equation. The weights used in the equation range from 0 (death) to 1 (perfect health).[42]

The DALY (disability-adjusted life year) approach is complementary to the QALY approach. Instead of representing individuals' quality of life, it measures their disability using an equation similar to that used by the QALY approach, albeit one in which the weighting is, in a certain sense, inverted. The disability-related weights disability range from 0 (no disability) to 1 (death). Moreover, in contrast to the QALY measure, which assigns the same value to each life year with the same health status (irrespective of age), the DALY measure assigns greater weight to the mid-life years and lower weight to the early (childhood) and late (retirement) years. In other words, the individual's working years are more highly valued.

[42] These weights may be determined by directly questioning the individuals concerned or by using weight tables developed from population surveys.

Figure 4.1 illustrates the complementarity of the two approaches. To simplify the comparison, we have purposefully not assigned greater weight to the mid-life years in the DALY approach. The figure depicts the situation of an individual stricken with a disease at age 20. The disease gives rise to a disability of 0.25 (and a quality of life of 0.75) and an early death at age 50. The disease thus results in 37.5 DALYs, based on a life expectancy of 80 years.

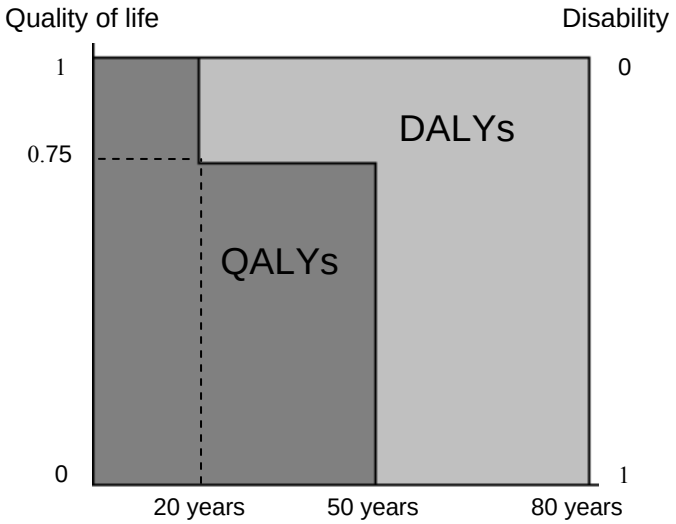

Figure 4.1: The complementarity of the QALY and DALY approaches: example of an individual with a 25% disability at age 20 and an early death at age 50

We will carry out the analysis of the costs of occupational injuries in terms of DALYs.[43] To calculate the number of DALYs, we have chosen to use the method recommended in World Health Organization (WHO), Harvard School of Public Health, and World Bank (Mathers et al., 2006; Murray and Lopez, 1996) studies, but have adapted it to the available data.

To calculate the number of DALYs resulting from an occupational injury, the number of potential years of life lost (YLL) due to early death and the number of years lost due to disability (YLD) are added together:

$$\text{DALY} = \text{YLL} + \text{YLD} \tag{6}$$

In the literature, there is a debate regarding the discounting of the future health of individuals. Those who are opposed to this type of discounting wonder why one year of life today should be worth more than one year of life later. While the debate is ongoing, the majority of economists agree on a certain form of discounting. Introducing a time preference, the two elements of equation (6) can be presented as follows:

$$\text{YLL} = \frac{1 - e^{-r n_d}}{r} \tag{7}$$

[43] The DALY indicator is closer to the notion of cost.

$$\text{YLD} = D \times \frac{(1 - e^{-r n_i})}{r} \tag{8}$$

where

- r is the discount rate;
- n_d is the number of years of life expectancy remaining at the age of death;
- n_i is the number of years of life expectancy remaining at the age of permanent disability or the duration of the temporary disability;
- D is the weight assigned to the disability (between 0 and 1);
- e is Napier's constant (2.718…).

The DALY approach generally assigns greater weight to the mid-life years and less weight to the years at the beginning and end of life using a weighting function.[44] This assumes that an individual's working years contribute more to society, a controversial practice not consistently found in the international literature (Jelsma et al., 2002). In our study, we decided not to attribute more weight to the mid-life years, since using such weights could lead to double-counting (Richardson, 2002). This can happen when an estimate of the costs of productivity losses (human capital) and human costs (DALY) are included in the same study. By estimating the productivity losses, the mid-life years are already given greater value.

For each of the occupational injuries found in our database, we applied the following equation:

$$\text{DALY} = \frac{1 - e^{-r n_d}}{r} + \left[D \times \frac{(1 - e^{-r n_i})}{r} \right] \tag{9}$$

The discount rate used is 3% (see section 2.7). Life expectancy as a function of age and gender was obtained from mortality tables published by Statistics Canada (2006). The disability-related weights (D) can be determined through two approaches. The first consists of using previously established weights based on population studies. For example, it would have been possible to use a weight table developed by the World Health Organization (WHO).[45] However, these tables are not an exhaustive list of all possible injuries. It is therefore necessary to find in that list the injury or disease most similar to the studied occupational injury or disease and then to use the weight assigned to it.

We decided instead to use a datum found in the CSST's administrative files, namely permanent physical and mental impairment (PPMI). This datum corresponds to the total of the percentages, determined according to the scale of bodily injuries, for the anatomicophysiological deficits, disfigurement, and suffering or loss of enjoyment of life resulting from the deficit or disfigurement (CSST, 2010b). The advantage of this datum is that it is based on the medical report written by the physician responsible for the injured worker. Thus, the assessment of the physical and psychological health is done in person and is therefore individualized.

[44] This function takes the form $Cxe^{-\beta x}$, where C and β are constants and x is the age in years.
[45] http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf

Temporary disabilities can be estimated using equation (8), simply by altering variable n_i so that it corresponds to the duration of disability, which is estimated on the basis of the number of compensated days. However, since these are not permanent disabilities, there is no PPMI and consequently no disability-related weight. It is therefore necessary to find a means for assigning a weight to these disabilities. Accordingly, the number of compensated days was used as a measure of the severity of the injury. To assign a weight to the numbers of compensated days, we used a weight table recommended by the U.S. Department of Transportation (2009). First, three intervals were created: 0 to 15 days, 15 to 180 days, and 180 days and over. Then, we correlated these intervals to the levels of severity in the U.S. Department of Transportation weight table (table 4.9).[46]

Table 4.9: Relative disutility factors by injury severity level

MAIS Level*	Severity of the injury	Weight	Compensated days
MAIS 1	Minor	0.0020	-
MAIS 2	Moderate	0.0155	[0; 15[
MAIS 3	Serious	0.0575	[15; 180[
MAIS 4	Severe	0.1875	[180; +∞
MAIS 5	Critical	0.7625	-
MAIS 6	Fatal	1.0000	-

* Maximum Abbreviated Injury Scale (MAIS)
Source: U.S. Department of Transportation (2009)

Of the 3,796 injuries in our database, which covers the injuries that occurred between 2005 and 2007, there are 27 injuries with a PPMI above 100%. A brief analysis of these injuries allowed us to determine that these were, in most cases, very severe injuries, such as cancer related to asbestos exposure. In theory, a weight (D) of 100% corresponds to death. We therefore decided to cap the PPMI at 100%. As a consequence, no injury or disease can be considered worse than death.[47]

Applying equation (9), we estimate that the occupational injuries that occur during one year in the Québec mining industry result in an average of 621 DALYs. In other words, the equivalent of 621 years of life in good health is lost due to the occupational injuries that occur in the mining industry each year.[48]

Although accurate, this estimate of the human costs is not expressed in monetary terms, which can be problematic when expressing the costs of occupational injuries as a single value. To obtain the monetary value of the human costs, we will use the willingness-to-pay method.

[46] We have assumed that minor injuries are not compensated injuries and that critical injuries are probably a PPMI.
[47] Some researchers claim that some injuries may have consequences worse than death.
[48] This figure may seem large but it arises from the fact that deaths and permanent disabilities have consequences for several years after the injury.

Willingness to pay

The willingness-to-pay (WTP) method consists of estimating the amount that an individual or a society is willing to pay or receive in exchange for a marginal change in the individual's risk (injury, disease, or death). Willingness to pay is a method used mainly for estimating the value of a statistical life (VSL).[49]

Lebeau and Duguay (2011) showed that it is possible to use a combination of the DALY approach and the willingness-to-pay method to express in monetary terms the DALYs resulting from occupational injuries. However, as we have already estimated the number of potential years of life lost (DALYs), we need merely to multiply this number by the value of one year of life in good health.

To estimate the value of one year of life in perfect health, the VLY must be isolated in the following equation:

$$VSL = \frac{VLY}{(1+r)} + \frac{VLY}{(1+r)^2} \cdots \frac{VLY}{(1+r)^{40}} \qquad (10)$$

where VLY is the value of a life year and r is the discount rate.

In this type of calculation, discounting is usually spread over 40 years because that is the approximate difference in workers' average (or mean) age and life expectancy.

The value of a statistical life used in this report is based on the *Guide de l'analyse avantages-coûts des projets publics en transport* published by the Québec transportation department (MTQ, 2007). The VSL used for our estimates is the same as the one used in this guide, i.e. $3,234,381 (2006). Inserting this figure in equation (10) gives us a VSL of $139,927.

However, several studies appear to indicate that a value of around $5 million (in 2000 Canadian dollars) would be more appropriate (Bellavance et al., 2009; Dionne and Lanoie, 2004; Knieser et al., 2007). We have gone with the MTQ value because our research suggests it is the only value that is actually used at the government level for assessing a project that impacts the health and safety of the Québec public. Moreover, using a lower value is in keeping with our desire not to overestimate the costs of occupational injuries.

Human costs for employers

For employers, the costs associated with pain, suffering, and loss of enjoyment of life are limited to claims for bodily injury paid to the injured. In the CSST database, these indemnities total $1,931,394 annually.

[49] See Lebeau and Duguay (2011) for more details about the methodological aspects of this method.

Human costs for workers

Multiplying the number of DALYs by the VSL gives us the total costs of occupational injuries for the workers, namely $86,828,668.

To separate out the human costs, the total financial costs assumed by the workers have to be subtracted. By subtracting financial costs (funeral expenses, salary costs, employee benefits, household work) of $8,849,565, the human costs assumed by the workers and their families are estimated at $77,979,103.

It is important to note that the bodily injury indemnities should not be subtracted from the total costs for the workers because, according to the model used, they are already anticipated by the workers. For the same reason, the total human costs are obtained by adding together the bodily injury indemnities and the human costs for the workers. Table 4.10 presents a summary of these costs, broken down by the party that assumes them.

Table 4.10: Human costs associated with the occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Bodily injury indemnities	$1,931,394	-	-	$1,931,394
Human costs net of compensation	-	$77,979,103	-	$77,979,103
Total	**$1,931,394**	**$77,979,103**	**-**	**$79,910,497**

5. ANALYSIS OF THE RESULTS

The following table presents the results of the estimates of the costs of occupational injuries in Québec mines.

Table 5.1: Costs associated with occupational injuries in one year in the mining industry, Québec, 2005–2007

	Employers	Workers	Community	Total
Medical costs				
Compensated medical costs	$2,984,593	-	-	$2,984,593
First aid	$13,047	-	-	$13,047
Nurses	$525,453	-	-	$525,453
Total	**$3,523,093**	**-**	**-**	**$3,523,093**
Transportation/emergency				
Transportation of the accident victim	**$194,910**	**-**	**-**	**$194,910**
Funeral costs				
Funeral costs	**$25,077**	**$31,590**	**$28,333**	**$85,000**
Salary costs				
Waste pay of the worker on the day of the accident	$148,169	-	-	$148,169
Waste pay of the other employees	$191,046	-	-	$191,046
Waste pay while on temporary assignment	$2,320,590	-	-	$2,320,590
Overtime	$719,651	-	-	$719,651
Total	**$3,379,455**	**-**	**-**	**$3,379,455**
Productivity losses				
Lost wages				
Indemnities (IRI + death benefits)	$14,855,943	-	-	$14,855,943
Drop in net earnings	-	$2,281,979	-	$2,281,979
Income tax and other deductions	-	-	$6,865,145	$6,865,145
Employee benefits	$4,126,258	$2,064,570	$2,210,245	$8,401,073
Household work				
Household work indemnities	$153,136	-	-	$153,136
Household work net of compensation	-	$4,471,426	-	$4,471,426
Total	**$19,135,337**	**$8,817,975**	**$9,075,390**	**$37,028,703**
Administrative costs				
Administrative costs of the CSST	$2,286,733	-	-	$2,286,733
Administrative costs related to accident files	$649,318	-	-	$649,318
Employee turnover costs	$1,182,986	-	-	$1,182,986
Total	**$4,119,038**	**-**	**-**	**$4,119,038**
Legal costs				
Legal costs	$1,376,334	-	-	$1,376,334
Commission des lésions professionnelles	$326,676	-	-	$326,676
Total	**$1,703,010**	**-**	**-**	**$1,703,010**
Subtotal	**$32,079,920**	**$8,849,565**	**$9,103,724**	**$50,033,209**
Human costs				
Bodily injury indemnities	$1,931,394	-	-	$1,931,394
Human costs net of compensation	-	$77,979,103	-	$77,979,103
Total	**$1,931,394**	**$77,979,103**	**-**	**$79,910,497**
Total cost of occupational injuries	**$34,011,314**	**$86,828,668**	**$9,103,724**	**$129,943,706**

Here are some of the key points that emerge from table 5.1:

- Human costs account for nearly 62% of the total cost and nearly 90% of the costs for workers;
- Productivity loss costs account for 56% of the costs for employers, 10% of the costs for workers, and nearly 100% of the costs for the community.

Costs by cost component

Figure 5.1 charts the proportion of each cost component making up the total estimated cost.

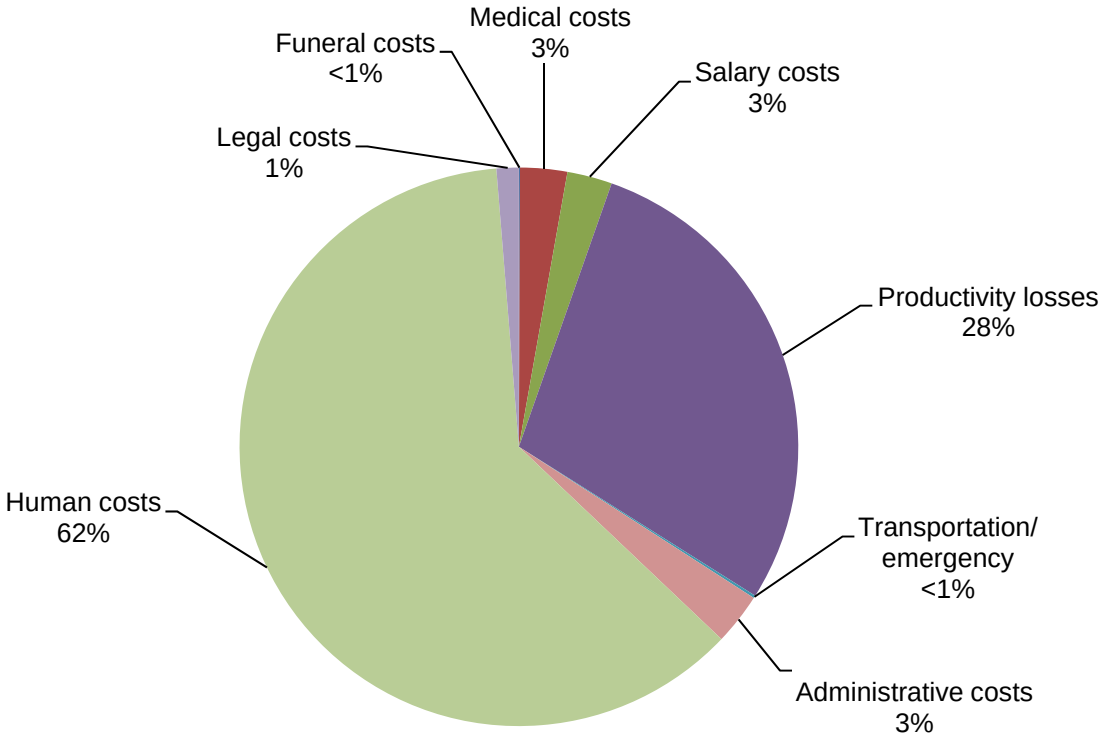

Figure 5.1: Costs of occupational injuries in the mining industry by cost component, Québec, 2005–2007

Costs by subsector

Examining the average cost of occupational injuries by subsector reveals significant differences (table 5.2). The asbestos industry in particular stands out with average costs of $325,100 per case, which is explained by the high number of occupational diseases and deaths in the industry.

Table 5.2: Cost of occupational injuries in the mining industry by subsector, Québec, 2005–2007

Subsector	Average annual number	Total cost	Average cost per case
Ore mining	1,108	$108,214,740	$97,696
Iron	248	$11,173,554	$45,055
Other metal ores	485	$45,060,811	$92,909
Asbestos	61	$19,831,116	$325,100
Other nonmetallic minerals	314	$32,149,259	$102,495
Support activities for mining and oil and gas extraction	158	$21,728,966	$137,816
Total	1,265	$129,943,706	$102,695

Costs by injury type

Occupational fatalities are the injuries with the highest average costs, followed by, in order, occupational diseases and accidents (table 5.3).

Table 5.3: Costs of occupational injuries in the mining industry by type of injury, Québec, 2005–2007

Injury type	Average annual number	%	Total cost	Average cost per case
Work accidents	1,101	87.0	$80,387,947	$73,014
Occupational disease	164	13.0	$49,555,759	$301,556
Total	1,265	100.0	$129,943,706	$102,695
Deaths	11	0.9	$21,924,522	$1,934,517
Accident-related deaths	4	0.3	$11,970,128	$2,992,532
Disease-related deaths	7	0.6	$9,954,394	$1,357,417

Also, as can be seen in figure 5.2, human costs constitute a significant portion of the cost of occupational injuries, particularly for deaths.

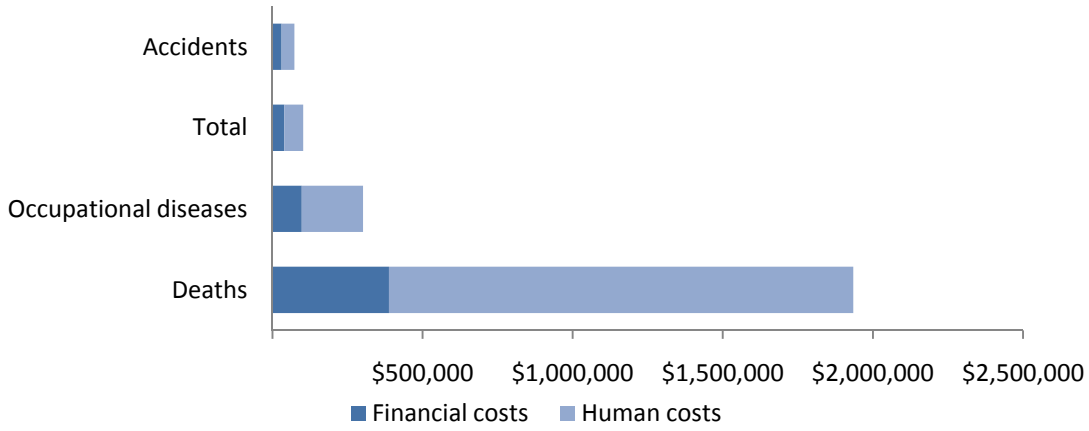

Figure 5.2: Average cost of occupational injuries in the mining industry by injury type and type of cost, Québec, 2005–2007

Costs by nature of the injury or disease

Table 5.4 presents the costs of occupational injuries broken down by the nature of the injury or disease, in decreasing order of average cost:

- Sprains and strains account for 32.1% of occupational injuries in the mines;
- Multiple injuries have average costs of $703,274 (ranked first). This type of injury is frequently associated with accidents that result in death;
- Other diseases—including most notably asbestosis, silicosis, and cancer, all diseases that can cause death—have total costs of $22,029,592 (ranked first).

Table 5.4: Cost of occupational industries in the mining industry by nature of injury or disease, in decreasing order of average cost per case, Québec, 2005–2007

Nature of injury or disease	One year of injuries (average)				Average per case			
	Nbr	%	Cost	Rank	Time loss (calendar days)	Rank	Cost	Rank
Multiple injuries	18	1.4	$12,424,511	5	166.5	4	$703,274	1
Other diseases	47	3.7	$22,029,592	1	170.3	3	$472,063	2
Other injuries	9	0.7	$1,423,196	10	25.4	12	$158,133	3
Pain (except back pain)	5	0.4	$767,479	13	121.0	6	$153,496	4
Fractures	108	8.6	$15,005,190	2	106.0	7	$138,509	5
MSK* disorders (except back disorders)	105	8.3	$13,439,123	3	197.2	2	$127,992	6
Disorders of the ear	56	4.5	$7,102,350	6	0.1	15	$126,077	7
Burns	29	2.3	$3,561,461	9	48.4	9	$121,413	8
Mental disorders	9	0.7	$755,675	14	209.8	1	$83,964	9
Foreign bodies	17	1.3	$1,032,314	12	11.2	13	$61,939	10
Dorsopathies	20	1.6	$1,182,926	11	141.4	5	$59,146	11
Open wounds, surface wounds	110	8.7	$5,420,242	8	26.4	11	$49,275	12
Bruises, contusions	190	15.0	$7,000,895	7	33.9	10	$36,912	13
Sprain/strain	406	32.1	$13,147,176	4	60.2	8	$32,409	14
Disorders of the eye (conjunctivitis)	21	1.7	$576,472	15	4.7	14	$27,451	15
Subtotal	**1,149**	90.8	**$104,868,602**	-	**73.1**	-	**$91,243**	-
Unknown or uncoded	116	9.2	$25,075,104	-	252.8	-	$216,165	-
Total	**1,265**	100.0	**$129,943,706**	-	**89.6**	-	**$102,695**	-

*MSK: musculoskeletal

Costs by event or exposure

Table 5.5 presents the costs of occupational injuries by event or exposure, in decreasing order of average cost:

- The most frequent type of event or exposure involves being struck by equipment or objects, overexertion, same-level falls, or being caught or crushed by equipment or objects;

- Exposure to harmful substances (e.g. chemical products, minerals) is the type of event or exposure with the highest total and average costs.

Table 5.5: Cost of occupational industries in the mining industry by event or exposure, in decreasing order of average cost per case, Québec, 2005–2007

Event or exposure	One year of injuries (average)				Average per case			
	Nbr	%	Cost	Rank	Time loss (calendar days)	Rank	Cost	Rank
Exposure to harmful substances	36	2.8	$21,666,597	1	159.1	4	$607,475	1
Transportation accident	24	1.9	$5,221,186	9	55.7	11	$214,569	2
Rubbed-abraded-friction	34	2.7	$6,596,738	5	258.2	1	$192,138	3
Repetitive motion	38	3.0	$5,418,964	7	232.4	2	$141,364	4
Caught or crushed	106	8.4	$14,325,221	2	66.2	10	$135,570	5
Exposure to noise	55	4.3	$6,985,579	4	0.1	18	$127,011	6
Fall and jump to lower level	50	4.0	$5,326,080	8	116.9	5	$106,522	7
Violent acts	4	0.3	$376,102	17	223.9	3	$102,573	8
Contact with temperature extremes	22	1.8	$2,124,869	13	20.4	16	$95,143	9
Struck by	213	16.8	$13,407,901	3	46.8	13	$63,047	10
Other NEC or UNS* event or exposure	65	5.1	$3,939,273	11	73.8	8	$60,604	11
Fall on the same level, slip, trip	125	9.9	$6,552,156	6	70.9	9	$52,557	12
Other overexertion	128	10.1	$4,795,633	10	77.2	7	$37,466	13
Overexertion in lifting	58	4.6	$1,981,115	14	81.0	6	$33,962	14
Bending-climbing-reaching	41	3.3	$1,365,392	16	33.8	15	$33,034	15
Other bodily reactions	55	4.3	$1,708,918	15	48.6	12	$31,261	16
Struck against	89	7.1	$2,517,569	12	39.9	14	$28,182	17
Foreign bodies	15	1.2	$114,716	18	4.2	17	$7,648	18
Subtotal	**1,158**	91.5	**$104,424,009**	**-**	**73.2**	**-**	**$90,150**	**-**
Unknown or uncoded	107	8.5	$25,519,697	-	267.3	-	$238,502	-
Total	**1,265**	100.0	**$129,943,706**	**-**	**89.6**	**-**	**$102,695**	**-**

*NEC: not elsewhere classified, UNS: unspecified

Cost by source of injury or disease

Table 5.6 presents the cost of occupational injuries by source of injury or disease, in decreasing order of average cost:

- More than one injury in five (20.9%) is related to bodily motion or position;
- The injuries attributable to motorized highway vehicles are the injuries that result in the highest average costs ($187,927);
- Minerals are the source that generates the highest total costs ($22,549,280).

Table 5.6: Costs of occupational industries in the mining industry by source of injury or disease, in decreasing order of average cost per case, Québec, 2005–2007

Source of injury or disease	One year of injuries (average)				Average per case			
	Nbr	%	Cost	Rank	Time loss (calendar days)	Rank	Cost	Rank
Highway vehicles, motorized	20	1.6	$3,695,903	9	85.0	8	$187,927	1
Plants, animals and minerals	120	9.5	$22,549,280	1	82.1	10	$187,911	2
Other vehicles	32	2.5	$5,285,154	7	108.5	3	$165,161	3
Chemicals and chemical products	24	1.9	$3,704,000	8	53.5	18	$156,507	4
Other sources	17	1.4	$2,686,693	12	36.5	22	$155,001	5
Noise	55	4.3	$6,985,579	5	0.1	27	$127,011	6
Machinery	99	7.8	$12,111,876	3	95.7	5	$122,756	7
Ground and indoor surfaces	24	1.9	$2,728,571	11	98.6	4	$112,133	8
Ground and outdoor surfaces	42	3.3	$3,086,519	10	87.6	6	$73,489	9
Sructural metal materials	79	6.3	$5,707,945	6	69.4	13	$71,949	10
Other parts and materials	107	8.5	$7,632,070	4	56.4	16	$71,328	11
Other instruments and materials	20	1.6	$1,253,832	16	71.1	12	$63,754	12
Stairs	7	0.6	$443,558	20	150.0	2	$63,365	13
Persons	4	0.3	$219,312	24	233.8	1	$59,812	14
Scrap, waste, debris	33	2.6	$1,941,296	13	10.9	24	$59,427	15
Machine, tool, and electric parts	24	1.9	$1,277,864	15	82.2	9	$53,994	16
Boxes, crates, and cartons	6	0.4	$302,191	21	76.8	11	$53,328	17
Bodily motion or position	264	20.9	$13,208,410	2	86.2	7	$50,032	18
Other containers	40	3.1	$1,877,516	14	68.9	14	$47,332	19
Other work structures or surfaces	20	1.6	$901,289	18	66.0	15	$45,064	20
Hand tools – powered	13	1.0	$524,764	19	42.0	20	$41,429	21
Other hand tools – nonpowered	25	2.0	$1,031,995	17	38.8	21	$40,737	22
Hand truck, dolly	1	0.1	$52,761	26	32.3	23	$39,571	23
Furniture	6	0.5	$247,130	23	53.1	19	$39,021	24
Wood, lumber	11	0.9	$271,092	22	54.8	17	$24,645	25
Cutting hand tools – nonpowered	7	0.6	$171,391	25	8.7	25	$24,484	26
Other building materials	1	0.1	$9,973	27	4.8	26	$7,480	27
Subtotal	**1100**	86.9	**$99,907,965**	-	**72.2**	-	**$90,825**	-
Unknown or uncoded source	165	13.1	$30,035,741	-	205.7	-	$181,668	-
Total	**1265**	100.0	**$129,943,706**	-	**89.6**	-	**$102,695**	-

Costs by injured body part

Table 5.7 presents the costs of occupational injuries by the injured body part, in decreasing order of average cost:

- The two body parts most frequently injured are the back (19.6%) and hands (16%);
- Chest injuries resulted in the highest total and average costs.

Table 5.7: Cost of occupational industries in the mining industry by injured body part, in decreasing order of average cost per case, Québec, 2005–2007

Body part	One year of injuries (average)				Average per injury			
	Nbr	%	Cost	Rank	Time loss (calendar days)	Rank	Cost	Rank
Chest	57	4.5	$22,019,045	1	109.6	5	$384,053	1
Body systems	47	3.7	$16,239,069	3	505.5	1	$345,512	2
Multiple body parts	62	4.9	$18,726,434	2	183.6	2	$300,424	3
Head	51	4.0	$7,387,491	7	60.3	13	$145,806	4
Other upper extremities	41	3.2	$5,813,538	8	106.0	6	$142,956	5
Ear	84	6.6	$10,174,897	5	7.1	18	$121,612	6
Other lower extremities	45	3.5	$4,104,191	10	67.9	9	$91,885	7
Wrist	42	3.3	$3,416,036	11	111.0	4	$81,985	8
Shoulder	68	5.4	$4,470,705	9	133.3	3	$65,425	9
Trunk - abdomen -groin	21	1.6	$1,269,127	17	65.4	11	$61,409	10
Foot/toe(s)	41	3.3	$2,371,645	14	63.2	12	$57,379	11
Cervical vertebrae	41	3.2	$2,225,580	15	80.0	8	$54,282	12
Ankle	62	4.9	$3,109,089	13	55.2	14	$50,147	13
Hand/finger(s)	202	16.0	$10,127,470	6	40.7	15	$50,136	14
Back	248	19.6	$11,887,345	4	86.6	7	$47,933	15
Eye	38	3.0	$1,770,006	16	8.0	17	$46,991	16
Knee	82	6.5	$3,402,431	12	67.7	10	$41,662	17
Elbow	31	2.4	$988,205	18	32.5	16	$31,878	18
Subtotal	**1262**	99.7	**$129,502,306**	**-**	**89.4**	**-**	**$102,644**	**-**
Other body parts (unknown)	4	0.3	$441,401	-	161.7	-	$120,382	-
Total	**1265**	100.0	**$129,943,706**	**-**	**89.6**	**-**	**$102,695**	**-**

Costs by economic agent

Figure 5.3 shows the cost of occupational injuries in the mines per the economic agent that assumes them.

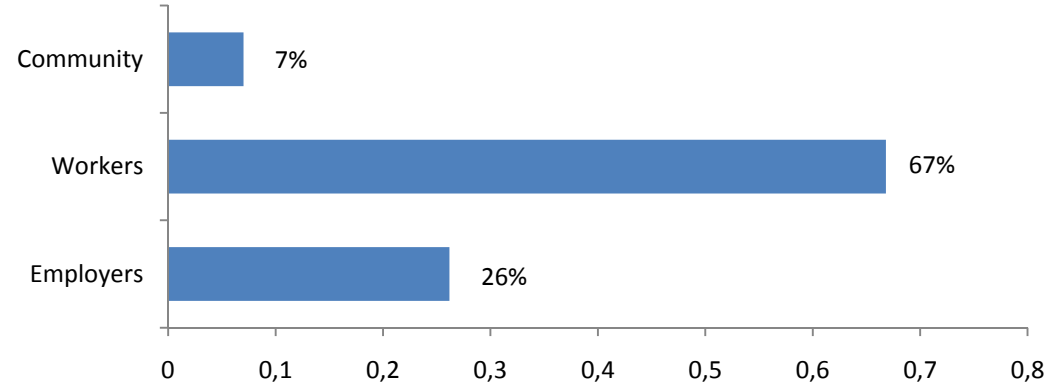

Figure 5.3: Costs of occupational injuries in the mining industry by economic agent, Québec, 2005–2007

Given the CSST data available to us, the costs for employers could be estimated only for an average period of about three years, except for injuries for which an income replacement indemnity could be estimated up to age 65 (see section 2.6). For their part, the costs for workers are usually estimated up to retirement or death. Thus, while these costs are quite thoroughly estimated, the costs borne by employers are only partially so. If we could estimate the complete costs for employers, they would likely be greater and would amount to more than 26% of the costs. This breakdown is therefore presented for illustrative purposes for all the costs that could be estimated on the basis of the data used in this report.

However, for the overall costs that we were able to estimate, the largest share is assumed by the workers, followed by the employers and the community (figure 5.3). This breakdown changes markedly when human costs are excluded from the estimates (figure 5.4).

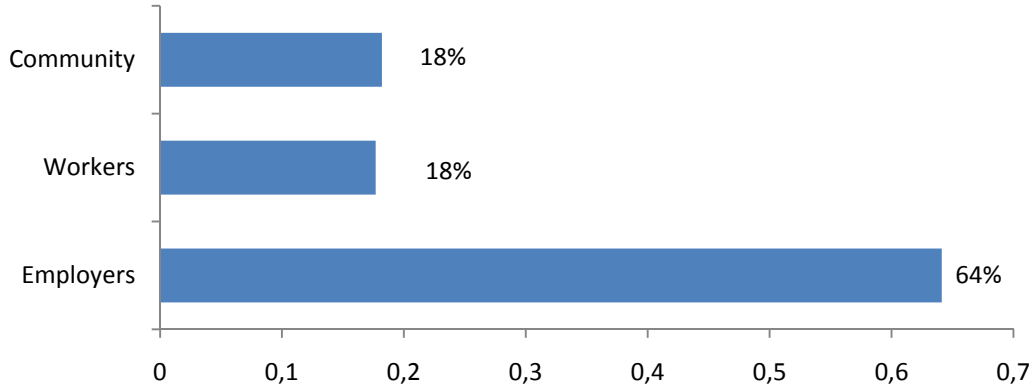

Figure 5.4: Costs of occupational injuries in the mining industry by economic agent, excluding human costs, Québec, 2005–2007

Table 5.8 presents the percentage of the total costs borne by each economic agent, broken down by injury type. We note that, among other things, the workers and their families bear about 90% of the cost of deaths. However, as mentioned earlier, the share assumed by the employers is probably underestimated.

Table 5.8: Costs of occupational injuries in the mining industry by economic agent and injury type, Québec, 2005–2007

Injury type	Employers	Workers	Community
Work accident	29.0%	64.0%	7.0%
Occupational disease	21.6%	71.4%	7.0%
Death	7.0%	90.3%	2.7%

Distribution by occupational category

The costs of occupational injuries are also broken down by occupational category (table 5.9):

- About 76% of injured workers work in manual trades.
- Injuries to non-manual workers result in average costs higher than those to manual and "mixed' workers.[50]

Table 5.9: Cost of occupational injuries in the mining industry by occupational category, Québec, 2005–2007

Occupational category	Nbr	%	Total cost	Average cost
Manual	966	76.3%	$89,116,869	$92,253
Non-manual	14	1.1%	$1,668,933	$122,117
Mixed	96	7.6%	$7,623,613	$79,689
Unknown	190	15.0%	$31,534,291	$165,970
Total	1,265	100.0%	$129,943,706	$102,695

Uninsured costs/insured costs

In the scientific literature, when analyzing costs at the societal level, the ratio of uninsured to insured costs or of indirect to direct costs is not usually calculated. This type of analysis is most appropriate for estimating costs in companies. For example, in Québec studies, the CSST costs are usually considered direct costs while indirect costs are all the other costs borne by the employers. By considering only the costs for employers, it was possible to calculate, using our estimates, a ratio of uninsured to insured costs of 0.51. Table 5.10 presents the costs for employers, separating the insured (CSST) costs from the uninsured costs.

[50] Among the injuries to non-manual workers, there was one death that significantly increased the average costs. Excluding this fatality lowers the average costs of injuries to non-manual workers to $92,641.

Table 5.10: Costs of occupational injuries in the mining industry (employers only), Québec, 2005–2007

	Insured costs	Uninsured costs	Total
Medical costs			
Compensated medical costs	$2,984,593	-	$2,984,593
First aid	-	$13,047	$13,047
Nurses	-	$525,453	$525,453
Transportation/emergency			
Transportation of the accident victim	-	$194,910	$194,910
Funeral costs			
Funeral costs	$25,077	-	$25,077
Salary costs			
Waste pay of the worker on the day of the accident	-	$148,169	$148,169
Waste pay of the other employees	-	$191,046	$191,046
Waste pay while on temporary assignment	-	$2,320,590	$2,320,590
Overtime	-	$719,651	$719,651
Productivity losses			
Lost wages			
Indemnities (IRI + death benefits)	$14,855,943	-	$14,855,943
Employee benefits	-	$4,126,258	$4,126,258
Household work			
Household work indemnities	$153,136	-	$153,136
Administrative costs			
Administrative costs of the CSST	$2,286,733	-	$2,286,733
Administrative costs related to accident files	-	$649,318	$649,318
Employee turnover costs	-	$1,182,986	$1,182,986
Legal costs			
Legal costs	-	$1,376,334	$1,376,334
Commission des lésions professionnelles	$326,676	-	$326,676
Human costs			
Bodily injury indemnities	$1,931,394	-	$1,931,394
Total cost of occupational injuries	**$22,563,552**	**$11,447,762**	**$34,011,314**

In the Brody et al. (1990) study, the authors obtained a ratio of 0.68 for the mining and quarrying industry. However, these two ratios are not comparable, as the cost components considered in the two studies are not the same. By using direct and indirect cost components comparable to those used in the Brody et al. (1990) study, we obtain a ratio of 0.69. In that case, the two ratios are nearly identical.[51]

Broadly speaking, Manuele (2011) suggests that an uninsured to insured costs ratio of around 0.8 would currently be appropriate for all industries. The author claims that the large increase in medical costs and indemnities in the last 15 years has caused this ratio to fall. In addition, the author claims that ratio less than 0.8 can even be observed for severe injuries, which result in higher insured costs.[52]

[51] We have not been able to compare the ratio obtained in Lavoie (2000) in a similar way. The author uses a definition of direct costs that was impossible for us to replicate.

[52] It should be noted that Brody et al. (1990) and Manuele (2011) define insured costs as being the medical costs and income replacement indemnities.

In the mining sector, injuries are, on average, more severe than in other industries. Some 24% of the accepted injuries involve a permanent physical and mental impairment (PPMI), for which the average rate is 12.4%. By way of comparison, for all industries during the same period, only 9% of the accepted injuries involve a PPMI, for which the average rate is 6.7%.

The weight of the most costly injuries

More detailed analysis of the results reveals that a large portion of the cost of occupational injuries is attributable to a small number of injuries. Figure 5.5 illustrates this phenomenon. The figure plots the total cost of occupational injuries against the percentage of the most costly injuries. As can be seen, 10% of the most costly injuries alone account for 74% of the total cost ($96 million) and 20% of the most costly injuries are responsible for 90% of the total cost ($117 million).

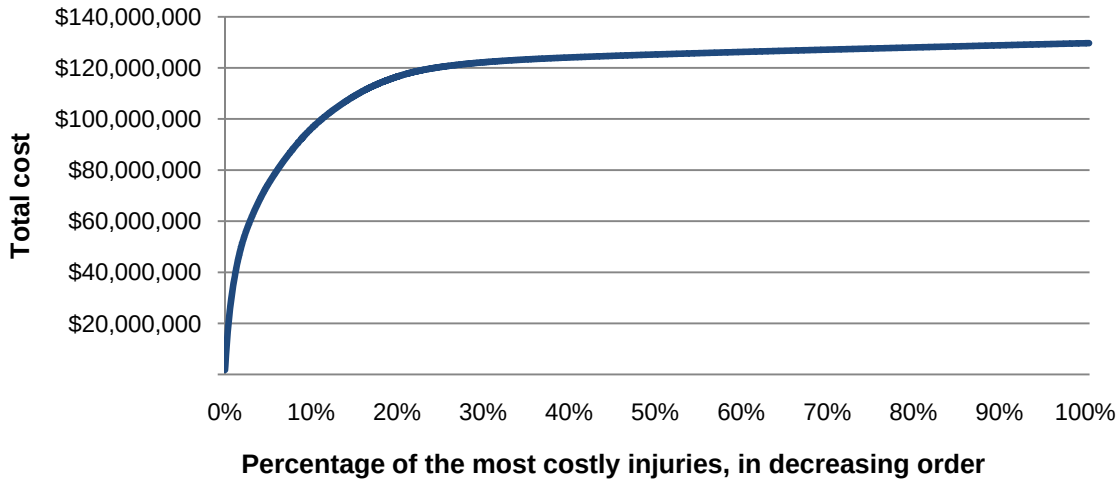

Figure 5.5: Impact of the most costly injuries on the total cost of occupational injuries in the mining industry, Québec, 2005–2007

6. LIMITATIONS

This section discusses the main limitations of this study. These consist mainly of cost components that were not estimated and of choices and methodological constraints that may have an impact on the estimates.

6.1 Unestimated cost components

Several cost components have not been estimated in this report. Generally speaking, the decision as to whether to include cost components was based on the availability and reliability of the data.

Property damage

It is very difficult to estimate the property damage resulting from occupational injuries. With the exception of in-house studies, very few studies have dared to include them in their estimates.[53]

Based on discussions with individuals in the mining industry, we conclude that occupational injuries in this industry are rarely accompanied by property damage. Lavoie (2000), who attempted to estimate the costs of work accidents in a Québec gold mine, arrived at the same conclusion:

> The equipment used by the workers is very heavy-duty and is only very rarely damaged. Property damage to finished or semi-finished products is non-existent. By its very nature, ore is not prone to damage. (Lavoie, 2000) [Translation]

This conclusion probably holds true for the majority of Québec mines. However, disasters that can generate significant property damage do occasionally occur. The rarity of these events means we cannot make generalizations about such costs that can be applied to all injuries.

Given the small amount of property damage related to occupational injuries in the mining industry and the great difficulty in estimating such costs, they cannot be included in the analyses.

It should be noted that property damage suffered by the workers involved in an accident is reimbursed by the CSST (clothing, prostheses, orthoses, glasses, lenses, hearing devices, etc.) and that these amounts are included in the medical aid costs.

Medical costs for workers

Medical costs may be borne by the injured worker if they are for supplementary medical products or services not part of the treatment recommended by the attending physician. However, we were unable to obtain any data of this type.

[53] Due to the sometimes spectacular and costly nature of some property damage, even a study carried out in companies over a period of time cannot accurately represent the average property damage costs.

Legal costs for workers

Injured workers may assume some legal costs. First, the decisions made by the CSST may be contested by the workers. In addition, the workers may take action against their employer on the grounds of liability or criminal negligence. However, no available data allow us to measure the scale of these costs.

Use of public services

At the community level, there is a cost for the government health care system, specifically with regard to the availability of limited resources. These costs cannot be adequately measured.

Some occupational injuries may also require the involvement of police or firefighters. These costs are assumed by the community through taxes. As it is very difficult to determine which injuries have required the involvement of police or firefighters and to estimate the costs of their involvement, those costs are not included in this report.

Also, some legal proceedings may entail a cost for the community in the form of the use of courts and legal staff. Such situations may arise in criminal negligence lawsuits or when a decision by the Commission des lésions professionnelles is contested in a non-administrative tribunal.

Waste pay of the injured worker on his return

On returning to work, the injured worker may not immediately perform at the same productivity level as before the injury, even after a temporary assignment. Brody et al. (1990) estimate this productivity loss at around $41.28 (in 1990 Canadian dollars) on average per accident and $430.02 for accidents involving a decline in productivity. However, only 19.1% of the injuries in their sample resulted in this type of cost. In the Lavoie (2000) study, in a Québec gold mine, it was not considered. Lacking sufficiently reliable data for estimating such costs for the mining industry, they were not estimated.

Lost wages due to a change in career path

An occupational injury can lead to a change in the worker's career path (loss of employment relationship, difficulty in obtaining a promotion, return to part-time work, etc.). If this change results in a pay cut and the difference in pay is not wholly compensated for by an indemnity, the worker has to absorb the loss. Several studies have shown that the average pay of injured workers is generally lower after the occupational injury (post compensation) than before the injury (Reville et al., 2001; Peterson et al., 1997).

In Québec, when a worker has to change jobs due to an occupational injury and the new job pays less than the pre-accident job, the CSST compensates the worker for the difference in pay. Hence, the amounts are included in the income replacement indemnity. However, these costs could be estimated only for an average period of about three years. Moreover, the lost wages that are not compensated by the CSST could not be estimated.

The government sometimes has to provide financial support to workers who do not succeed in returning to the job market and who no longer receive compensation from the CSST. An IRSST survey of workers who had gone through a rehabilitation process confirms this point (Baril et al., 1994). However, it is difficult to identify these workers and estimate the cost of lost wages. It is also difficult to estimate the share of these costs that is borne by the community (e.g. social assistance).

Reputation

Work accidents with injuries can have a negative impact on the reputation of the employer and the worker. For the employer, a work accident, especially one covered by the media, can affect its ability to recruit new employees and obtain new contracts. A worker who has suffered one or more severe occupational injuries may have trouble finding a new job. These costs are not usually considered in applied studies and are not estimated in this report.

Other human costs

In this report, we consider only the human costs for the worker and those in his circle. However, the injury may also result in human costs for other individuals. For example, at the workplace, these can take the form of tension in labour relations or of stress and anxiety in co-workers. At the community level, the costs can be reflected in the injured worker's non-participation in economic, social and political life. None of these costs were estimated.

6.2 Available data

The data used in this report can be classified into two categories: CSST administrative data and other data. In both cases, significant limitations should be noted.

CSST data

There are three limitations to using the CSST's administrative data. First, these data concern only injuries reported to the insurer and not all the injuries occurring in the workplace. A Canadian study (Shannon and Lowe, 2002) estimates the underreporting of eligible injuries to provincial occupational injury compensation boards to be 40%. Thus, this element tends to underestimate the "real" cost of occupational injuries in mines. However, this does not necessarily mean that the costs are underestimated by 40%, as the main factor associated with the non-reporting of injuries is the severity of the injury; less severe injuries are those most likely not to be reported and also those that are the least costly.

Second, the disbursements have an average maturity of about three years.[54] This means that the data used do not include disbursements that occurred after the maturity period.[55] This is especially the case for injured workers no longer likely to return to work, and it may generate costs over a period much longer than three years.

[54] An average maturity of three and a half years for injuries occurring in 2005 and of three years for injuries occurring in 2006 and 2007.

[55] Except for a few injuries where it was possible to predict future income replacement indemnities.

It should be noted that the estimates of the other cost components are not limited in time. For example, human costs are estimated for the workers' life expectancy. Thus, it is clear that the costs insured by the CSST are not evaluated on the same time scale as the other costs, which tends to underestimate the CSST costs borne by employers. Consequently, the breakdown of the costs assumed by the employers, the workers, and the community should not be viewed as representative of the overall costs of occupational injuries, as the costs for employers are underestimated. This division is provided for information purposes, based on the limitations of the data used.[56]

Third, the gross pay of the injured workers, as obtained from CSST records, tend both to underestimate and to overestimate the workers' actual pay. The pay is initially underestimated because it can be no higher than $99,999.99. The pay is then overestimated because it cannot be less than the annualized minimum wage (full-time). Thus, it may be that some seasonal or part-time workers receive an income replacement indemnity higher than what they would normally have earned. The gross pays obtained from CSST records therefore result in both an underestimate and an overestimate of the wages lost by the workers.[57]

Other data

The use of data from non-CSST sources increases the inaccuracy in the estimates. This is because these data do not correspond to the costs specific to the Québec mining industry as a whole but are often averages obtained from other studies.

Generally speaking, the uninsured costs assumed by employers are difficult to estimate and necessitate the use of external sources. For example, some costs were estimated by referring to the Lavoie (2000) study, which estimates the indirect costs of work accidents in a Québec mining company. The results obtained by the author made it possible to estimate, in our study, cost components that would not have been possible to estimate otherwise. However, it is impossible to know whether the Lavoie (2000) results are representative of the entire industry. The same is true for all external sources used in this report.

6.3 Sensitivity analysis

Because the data in this report are drawn from many sources and the estimates are made using several models and hypotheses, it is difficult to present a sensitivity analysis of the estimates.

However, it is possible to measure the impact of a variation in two significant parameters on the total costs of the occupational injuries (table 6.1). We note that a change in the value of a statistical life leads to a significant variation in the estimated total costs, while the impact of a change in the discount rate is not as significant.

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[56] As the goal of the methodology developed here is eventually to compare industries with other industries, this bias will be less significant. Basically, the cost estimates will be made using the same method with the same data sources, thereby producing comparable indicators.

[57] It should also be noted that the average pay per subsector (table 3.3) was used in cases where the injured worker's pay was not available in the database.

Table 6.1: Range of estimated total costs as determined by a change in the value of two parameters

Parameters	Range	Lower limit	Upper limit
Value of a statistical life (VSL)	$1M–$5M	$69,960,567	$177,342,682
Discount rate (r)	1%–5%	$122,522,778	$136,889,408

6.4 Human costs

Despite these efforts to assign a monetary value to life and to individuals' quality of life, this type of estimate will always remain debatable. However, omitting human costs would result in a significant underestimation of the costs of occupational injuries.

Regarding the choice of the value of a statistical life (VSL), Bellavance et al. (2009) hold that it is important to use a value that is representative of the population under study. As no estimate has been done in Québec, we have opted for the value used by the Québec transportation department, i.e. $3,234,381 (2006).[58]

Because human costs represent such a large share of the total costs of occupational injuries, using different values has a significant impact on the estimates. As shown in table 6.1, the choice of VSL has a significant impact on the total cost estimates. A similar approach is used in table 6.2, which presents the financial costs and human costs for three different VSLs.

Table 6.2: Variability of estimates according to the value of a statistical life

Value of a statistical life (VSL)	Financial costs	Human costs	Total costs
$1,000,000	$50,033,209	$19,927,358	$69,960,567
$3,234,381	$50,033,209	$79,910,497	$129,943,706
$5,000,000	$50,033,209	$127,309,473	$177,342,682

We note that human costs are lower or higher depending on which VSL is selected, mainly due to the VSL's impact on the estimated human costs. Actually, as nearly all the estimated human costs are assumed by the workers, this also has an impact on the share of the costs assumed by each of the parties (employers, workers, and the community).

Moreover, using permanent physical and mental impairment (PPMI) in the estimating of human costs also constitutes a limitation. Because a given PPMI rate does not necessarily have the same impact on each individual, it is possible that the estimates underestimate or overestimate the "real" individual human costs.

For example, take two individuals who have had a finger amputated due to an occupational injury. Now suppose that the injury results in a PPMI of 10% for each of them. If one of the two individuals likes to watch television in his free time, while the other prefers playing the piano, the

[58] In a Transport Canada (2008) document, a value of a statistical life of $3,050,000 (2000) is used in a scenario considered low.

impact of the injury will not be the same for the two individuals. However, in our estimates, both individuals will have identical human costs, all other factors being equal.

6.5 Net costs

In this report, it was decided not to include costs that might have been avoided or reduced due to occupational injuries. The estimates therefore do not take into account the net costs of occupational injuries. In this section, we present a few cost components that could have been estimated using this notion of "net costs."

Employee turnover costs

As companies have a pre-accident employee turnover rate, any replacement of personnel resulting from occupational injuries would still have been required at some later point in time (e.g. retirements, dismissals, and resignations). Thus, the net cost corresponds to the cost of recruiting now instead of later.

Funeral costs

Funeral costs are also costs that would normally have to be paid later. The net cost is thus the cost of having to organize these funerals prematurely.

Productivity losses

In this report, productivity loss estimates do not assume that a worker who is no longer working (injured or deceased) might be replaced by a worker who is not in the labour market (e.g. unemployed). Such a situation would result in advantages for the new worker (pay increase) and for the community (reduction in government-provided financial assistance, increase in income tax revenue). Accounting for these benefits would significantly reduce the productivity losses estimated in this report.

Doing so would mean applying a methodology similar to the friction cost method. This method holds that the full employment hypothesis advanced by the human capital method is unsustainable in the reality of the labour market.[59] A full employment situation may exist in some areas of the economy but probably not for the entire economy.

The friction cost method limits productivity losses (lost wages) to the friction period, which is the time necessary to return productivity to the level it was at prior to the accident. However, this friction period is difficult to estimate.

The friction cost method was not used in this report. First, in the particular context of the Québec mining industry, a full employment hypothesis is not unrealistic, as it is an industry experiencing a significant labour shortage. In addition, as Johannesson and Karlsson (1997) note, there is no assurance that an injured worker will be replaced by an unemployed person. For example, the

[59] A full employment situation occurs when unemployment is reduced to frictional unemployment, i.e. unemployment of short duration between the end of one job and the beginning of another.

replacement worker could come from another employer, thereby creating another friction period at his former company. Neither is it certain that this domino effect, from one employer to another, will end with an unemployed person entering the labour market.

Other elements

Depending on the particular situation of each worker, there may be other costs or constraints that are avoided due to the occupational injury. Here are a few examples:

- Lower transportation costs for an injured worker who is off work;
- The pay and mandatory employee benefits saved by the employer if the injured worker's workload has not been replaced (e.g. during a slowdown);
- The increase in available time for the injured worker due to his leaving work.

7. CONCLUSION

Occupational injuries entail significant economic and human costs for all of society. It is important to be able to use reliable estimates of these costs in order to optimize decision-making in the areas of prevention and research.

This study made it possible to test, using available data, methods for estimating the costs of occupational injuries, to draw a portrait of these costs in the Québec mining industry, and to identify limitations that could influence the development of economic indicators at the IRSST.

The annual cost of occupational injuries in the mines is estimated at approximately $130 million (in 2006 dollars) on average for the 2005–2007 period. Of this amount, nearly $50 million is allocated to financial costs (medical costs, productivity losses, lost wages, employee benefits, etc.) and $80 million to human costs. The average cost of an occupational injury totals $102,695. Due to the limitations of the methodology used, this is probably an underestimate of the cost of occupational injuries in the mines.

Analysis of the results also showed that the workers assume approximately 67% of the total costs, largely due to human costs. For their part, the employers assume nearly 64% of the financial costs.

Two methods found in the scientific literature were used to make these estimates. First, the human capital method was used to estimate productivity losses. Then a health status index was used in combination with the willingness-to-pay method to estimate the human costs in monetary terms.

This exercise also made it possible to identify certain limitations that could influence the development of economic indicators at the IRSST. The most significant limitation concerns data availability. Some estimates required the use of external sources (mining companies, research work, etc.). Such sources can probably not be used for all industries in Québec.

Broadly speaking, this study demonstrates that it is possible to estimate the costs associated with occupational injuries and that the IRSST has the data necessary to apply the methods used in the scientific literature. However, the limitations identified in this report allow us to affirm that it would be difficult to produce such complete estimates for all industries.

8. AVENUES FOR FURTHER REFLECTION

In light of the estimates made in this report, we can confirm that some cost components are very difficult to estimate, especially costs that are borne by employers but not insured by the CSST. In this study, we were able to survey several Québec mining companies in order to estimate some of the uninsured cost components. However, that cannot be done for each of Québec's industries. Moreover, we were able to refer to a study (Lavoie, 2000) whose objective was to estimate the indirect costs of work accidents in a Québec gold mine. Unfortunately, no study of this type exists for any other industry.

Although this reality would appear, at first glance, to compromise the development of economic indicators at the IRSST, it should be stressed that a complete estimate of the costs of occupational injuries is not necessary in every circumstance. The IRSST would like to use these indicators in order to develop a cost-based ranking, i.e. to arrange categories of workers and types of injuries by cost. In such a context, it is probably not necessary to estimate all the costs associated with occupational injuries. Moreover, it would be more judicious to use only the larger costs elements for which data are easily available and properly measured. For example, compensated medical costs, productivity loss costs, and human costs account for some 92% of the total estimated costs in this study, and they are estimated wholly or partly on the basis of CSST administrative data. An indicator composed of these three elements would thus be relatively easy to estimate and would likely be representative of the total costs estimated in this study.

Several avenues of inquiry should also be considered in order to improve the accuracy of the estimates. First, because the human cost estimates are based on the workers' lifespan, it would be interesting if the CSST's costs were not limited to an average maturity of three years. Although in this study it was possible to predict the future income replacement indemnities paid to some types of injured worker, these amounts underestimate all of the CSST costs that do not appear in our database. It would also be interesting to study how disbursements related to occupational injuries change over time, over a period of several years. Such analyses would make it possible to project the CSST's costs and would help ensure a better estimate of the costs of occupational injuries with regard to incidence.

In addition, a survey of companies could help obtain data more representative of the uninsured costs for employers. If carried out, such a survey should target each sector of economic activity and involve a sufficiently high number of companies to be representative of the sectors. Instead of using a simple survey distributed to the companies, an online tool could be developed. The tool would allow the participating companies to measure the scale of the uninsured costs in their organization and at the same time would provide data very relevant to the carrying out of various economic studies at the IRSST. However, a survey of this type would require significant resources.

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APPENDIX 1: NAICS CODE DETAILS (2002)

2122	**Metal Ore Mining**
21221	Iron Ore Mining
212210	Iron Ore Mining
21222	Gold and Silver Ore Mining
212220	Gold and Silver Ore Mining
21223	Copper, Nickel, Lead and Zinc Ore Mining
212231	Lead-Zinc Ore Mining
212232	Copper-Nickel Ore Mining
212233	Copper-Zinc Ore Mining
21229	Other Metal Ore Mining
212291	Uranium Ore Mining
212299	All Other Metal Ore Mining
2123	**Non-metallic Mineral Mining and Quarrying**
21231	Stone Mining and Quarrying
212314	Granite Mining and Quarrying
212315	Limestone Mining and Quarrying
212316	Marble Mining and Quarrying
212317	Sandstone Mining and Quarrying
21232	Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying
212323	Sand and Gravel Mining and Quarrying
212326	Shale, Clay and Refractory Mineral Mining and Quarrying
21239	Other Non-metallic Mineral Mining and Quarrying
212392	Diamond Mining
212393	Salt Mining
212394	Asbestos Mining
212395	Gypsum Mining
212396	Potash Mining
212397	Peat Extraction
212398	All Other Non-metallic Mineral Mining
2131	**Support Activities for Mining and Oil and Gas Extraction**
21311	Support Activities for Mining and Oil and Gas Extraction
213111	Oil and Gas Contract Drilling
213117	Contract Drilling (except Oil and Gas)
213118	Services to Oil and Gas Extraction
213119	Other Support Activities for Mining

APPENDIX 2: COST COMPONENTS OF OCCUPATIONAL INJURIES

		Society		
Costs	**Definition**	**Employers**	**Workers[1]**	**Community[2]**
Medical costs	Expenses incurred (or projected) to treat the injury	First aid Medical aid costs Rehabilitation costs Private nurses	Uncompensated medical expenses	Spending on the government health care system (resource availability)
Property damage	Property damage that occurred at the time of the accident	Property damage (machines, cleaning, etc.)		-
Transporta-tion/ emergency	Transportation and emergency services that may be used due to an occupational injury	Transportation (ambulance, etc.)	-	Police Firefighters
Funeral costs	All costs incurred to bury a deceased worker	Compensated funeral costs	Funeral costs (net of compensation)	RRQ death benefits
Salary costs	Unworked (or non-productive) hours that are nonetheless paid for in the form of wages and employee benefits by employers	Waste pay of the injured worker on the day of the accident Waste pay of the other employees Waste pay of the accident victim on temporary assignment Waste pay of the accident victim on his return Overtime pay	-	-
Productivity losses	<u>Lost wages</u> Gross earnings of the worker off work due to an occupational injury	Income replacement indemnities Death benefits	Lost wages (net of compensation) Reduction in pay due to a change in career path (net of compensation)	Uncollected income taxes Government assistance in the form of supplementary income

Costs	Definition	Employers	Workers[1]	Community[2]
	Employee benefits Value of the employee benefits that the worker receives in addition to his pay	Employee benefits assumed by the employer for a non-productive employee	Lost employee benefits	Employee benefits assumed by the community
	Household work Value of unpaid household work	Compensated household work	Inability to perform household work (net of compensation) Extra work for the other members of the household	-
Administra-tive costs	All management costs resulting from an occupational injury (e.g. follow-up, hiring, records management)	Recruitment Training Investigation/Accident file management CSST administrative fees	-	-
Legal costs	Costs resulting from legal proceedings	Medical disputes Legal defence Lawsuits Funding of the Commission des lésions professionnelles (CLP)	Medical disputes Legal defence Lawsuits	Use of government services (courts, legal staff, etc.)
Reputation	Financial losses related to the negative image that an occupational injury can create	Loss of contracts Recruitment problems	Difficulty finding other work due to the occupational injury record	-
Human costs	Value of the change in the quality of life of the worker and those around him as well as the length of these changes and, in cases of death, the potential years of life lost	Possible tensions in labour relations Stress and anxiety in the other workers Compensated human costs	Pain, anxiety, stress, and loss of enjoyment of life affecting the accident victim, family members, and friends (net of compensation) Family problems	Reduction of the accident victim's participation in the community's economic, social, and political life

[1] The costs for the workers also include the costs for those in their circle (family and friends).
[2] These are specific costs assumed by other economic agents in society and the general costs assumed by all of society, including employers and workers.