Statistical Surveillance Group

Studies and Research Projects

REPORT **R-843**

The Costs of Occupational Injuries in Québec, 2005-2007

Martin Lebeau
Patrice Duguay
Alexandre Boucher

irsst

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PEER REVIEW

In compliance with IRSST policy, the research results published in this document have been peer-reviewed.

CAUTION

The results presented in this document have been produced for use in occupational health and safety research and prevention planning. They were obtained using data from CSST administrative files and Statistics Canada surveys and censuses. However, the data have been processed by the IRSST for its own purposes. Thus, due to methodological differences, in particular differences related to the concepts, data selection criteria, and data maturity, the results may differ slightly from other published results based on these data sources. Care should therefore be taken when comparing these results with those of other publications.

SUMMARY

Studies on the costs of occupational injuries in Québec are quite rare. The few Québec studies retained estimate the costs specific to companies. This study innovates by estimating the overall costs—human as well as financial—of occupational injuries.

It does so by using the human capital method to estimate the productivity losses. Then, for each injury accepted by the Québec workers' compensation board (CSST), the human costs are estimated using a health status index in combination with an estimate of the value of a statistical life obtained using the willingness-to-pay method. The estimates are produced mainly using individual data from the CSST.

The overall costs of the occupational injuries occurring in one year in Québec are estimated at an average $4.62 billion for the injuries from the 2005–2007 period. Of this amount, $1.78 billion is attributed to financial costs and $2.84 billion to human costs. The average cost of an occupational injury totals $38,355. Due to the limitations of this study, these costs are probably underestimated.

Analysis of the results allows us to identify the injury descriptors and industries for which the costs are the highest. We note, among other things, that noise exposure injuries are those with the highest average cost per injury.

Analysis of the costs per industry shows the main industries of the priority groups targeted by the CSST (e.g. mining, forest products, construction) to head the list, along with industries not among the top priority groups (e.g. waste management and remediation services).

This study provides a clearer understanding of the magnitude of the costs related to occupational injuries in Québec. The results of these estimates are a relevant source of information when determining research directions in OHS and prevention.

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GLOSSARY

Accepted injury	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*.
Body part	The part of the body that is directly affected by the nature of the specified injury or disease.
CLP	Commission des lésions professionnelles, the administrative tribunal of last resort for workers and employers who are dissatisfied with a CSST decision.
Costs for employers	In this report, costs for employers are the costs specific to employers of workers who have suffered injuries as well as some general costs assumed by the other employers in the industry or by all Québec employers insured by the CSST.
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 the 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 (OMS, 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.
Event or exposure	Type of accident or exposure describing how the injury or disease was produced or inflicted by the source of injury (e.g. same-level fall, road accident, repetitive motion).
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).
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.
Lost-time injury	An accepted injury (as defined above) with a positive total number of compensated days and a positive IRI total, excluding cases involving a death related to the injury.
Manual occupations	Occupations in which physical activity plays a predominant role (construction jobs, unskilled labour, specialized workers, etc.).
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.
Nature	Nature of the injury or disease, indentifying the injury's or disease's main physical characteristics (e.g. sprain, fracture, cut).
Non-manual occupations	Occupations in which physical activity plays a minor role (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.
Source of injury	The causal agent of the injury, describing the object, substance, exposure, or bodily motion that resulted in or directly inflicted the previously specified injury or disease (e.g. rasping machine, jigsaw, cutting oil).
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 per se; 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

This research project is part of the IRSST's effort to develop economic indicators in the occupational health and safety field on which decisions regarding research priorities, among other things, can be based. More specifically, the project aims to estimate the costs of occupational injuries in Québec for the injuries that occurred during the years 2005 to 2007.

Occupational injuries are costly for the companies concerned but also for society as a whole. In 2010, Québec employers paid some $2.3 billion in contributions to the Commission de la santé et de la sécurité du travail (CSST, 2011). To that amount can be added other uninsured cost components, which are harder to measure.

This study uses methods employed in the literature to estimate the overall costs, financial as well as human, resulting from occupational injuries. The results are then broken down by, among other things, injury descriptor and industry.

This report is divided into six chapters. Following the introduction, the second chapter describes the research design. The third chapter presents the cost estimates for occupational injuries, while the fourth chapter is devoted to the analysis of the results. The fifth chapter focuses on the limitations encountered in this study's estimates. Lastly, a conclusion is presented in the sixth chapter.

2. RESEARCH DESIGN

2.1 Background

A feasibility study carried out in the mining industry (Lebeau et al., 2013) made it possible to identify certain limitations that could influence the development of economic indicators at the IRSST. The most significant is the availability of data. Some estimates relied on external sources (mining companies, research work, etc.); such sources cannot be drawn upon for all Québec industries.

The feasibility study nonetheless allowed the authors to conclude that the costs resulting from occupational injuries can be estimated and that the IRSST has the data necessary to apply the main methods used in the scientific literature. However, the limitations encountered reveal that it would be difficult to produce for all industries estimates as complete as those produced for the mining 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. Actually, the IRSST would like to use these indicators to develop a cost-based ranking, i.e. to arrange categories of workers and types of injury by cost. For such uses, it is probably not necessary to estimate all the costs associated with occupational injuries but rather to estimate the costs of each of the injuries using the same methodology.

This study therefore aims to estimate the costs of occupational injuries in Québec. The methodology used (Lebeau et al., 2013) includes only cost components for which properly measured data are easily available. These cost components, which are presented in section 2.5, represent approximately 93% of the total costs estimated in the feasibility study of Lebeau et al. (2013).

2.2 Statistical population studied

The population considered in this study consists of all workers covered by the Québec occupational health and safety plan. For this population, the analyzed occupational injuries relate to occupational accidents and diseases whose causal event occurred between January 1, 2005, and December 31, 2007. In this context, these were therefore new cases of occupational accidents and diseases occurring during this period, being recognized and accepted as such by the CSST, the Québec occupational health and safety board. For the purposes of this study, the terms *injury* and *occupational injury* are used equivalently and, unless otherwise noted, refer to injuries reported to and accepted by the CSST.

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 and accepted injuries and on the disbursements, i.e. the financial data related to the injuries.

As there is no precise measurement of the number of workers covered by the Québec occupational health and safety plan, we have used the estimates made as part of another IRSST

study (Duguay et al., 2012). That study used the number of paid workers and hours worked found in the 2006 census of Canada's population (personalized tables). Taking the monthly data from Statistics Canada's Survey of Employment, Payrolls and Hours (SEPH), the census data were adjusted to account for the monthly fluctuations in the numbers of individuals and hours worked during the 2005–2007 period. The method for calculating the number of full-time equivalent (FTE) workers is presented in Duguay et. al. (2012).

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.[1] 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 data reduces the impact of annual fluctuations in injuries, which may be caused by exceptional events or economic shocks.

The disbursements are grouped into five categories:

- medical aid costs;
- rehabilitation costs;
- death benefits;
- bodily injury indemnities; and
- income replacement indemnities (IRI).

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, 2013) estimate the costs of occupational injuries only for employers. In the scientific literature, however, the majority of studies opt instead for an all-encompassing 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 this perspective is not a mere tallying of the costs for workers, employers, and the community. Attention must also be paid to transfer payments, such as the compensation paid to the injured workers. From a societal standpoint, 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, there appears to be no consensus in the literature regarding the cost components included in the each of the

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

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. The distinction between direct and indirect costs is not truly relevant to the societal perspective. A classification of costs based on who pays for them is probably more appropriate.

Table 2.1 presents the cost components estimated in this study.

Table 2.1: Estimated cost components of occupational injuries

Costs	Employers	Workers	Community
Medical costs	Medical aid costs Rehabilitation costs	–	–
Funeral costs	Compensated funeral costs	Funeral costs (net of compensation)	QPP death benefits
Salary costs	Waste pay of the injured worker on the day of the accident	–	–
Productivity losses	Lost wages Income replacement indemnities Death benefits	Lost wages (net of compensation)	Uncollected income taxes
	Employee benefits Employee benefits assumed by the employer for a non-productive employee	Lost employee benefits	Employee benefits assumed by the community
	Household work Compensated household work	Inability to perform household work (net of compensation)	–
Administrative costs	Recruitment and training	–	–
Human costs	Bodily injury indemnities	Pain, anxiety, stress, and loss of enjoyment of life affecting the victim, family members, and friends (net of compensation)	–

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 only 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).

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.[2] 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 occurred. 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 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 is not 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[3] is unemployable due to his age.[4] 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.

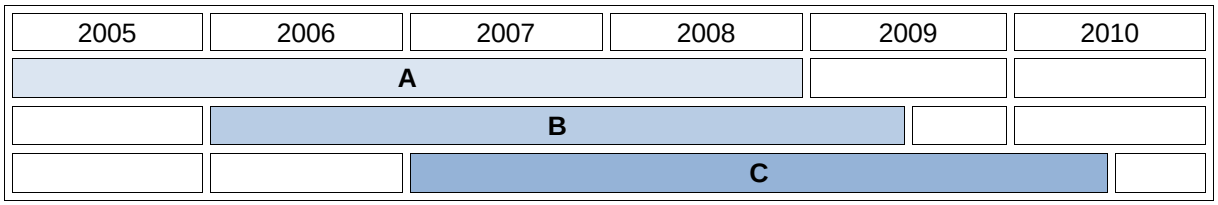
Table 2.2 makes it easier to understand the time dimension in this study. Shaded zones A, B, and C correspond to the disbursement periods for injuries that occurred in 2005, 2006, and 2007 respectively and that are used in our estimates.

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

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

[4] 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).

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



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 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 cash flow F can be expressed as:

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

where

- F^* is the discounted value of the cash flow;
- F is 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, which is the case in the environment and preventive health fields and 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, 2013), it is reported that the discount rates used in the 40 applied studies that were retained 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.[5]

Moreover, due to rounding, the totals shown in the tables do not necessarily equal the sum of the parts.

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

3. COSTS OF OCCUPATIONAL INJURIES

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.

3.1 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 who have had an accepted accident are borne by employers through their CSST contributions. These are mainly medical aid costs and rehabilitation costs.

Medical aid costs have several components. 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. However, as the household production costs are estimated in another section of this report (section 3.4.3) and as it was possible to separate them from the rehabilitation costs, we have subtracted those amounts. Thus, the medical costs total $235,890,077 (table 3.1).

Table 3.1: Medical costs associated with accepted occupational injuries in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Medical aid costs	$213,746,031	-	-	$213,746,031
Rehabilitation costs	$22,144,046	-	-	$22,144,046
Total	**$235,890,077**	**-**	**-**	**$235,890,077**

3.2 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 granted 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 $469,180 for the accepted injuries occurring in one year during the study period.[6]

Funeral costs for the community

The funeral costs assumed by the community are limited to the death benefits granted by the Québec pension plan (the QPP), 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 QPP. We assume this is the case for all the deaths in our sample. The total amount of the QPP death benefits is estimated at $447,500 for the accepted injuries occurring in one year during the 2005–2007 period.

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 and the QPP. The funeral costs assumed by the victims' families are estimated as the difference between $7,500 and the funeral costs reimbursed by the CSST and the QPP.

The deaths that occurred one year resulted in funeral costs estimated at $1,349,457 (table 3.2). Of this amount, $469,180 is paid by employers in the form of benefits to families and $447,500 by the community in the form of death benefits from the QPP. The remainder, i.e. $432,776, is assumed by the deceased workers' families.

Table 3.2 presents a summary of the funeral costs assumed by the various economic agents.

[6] As the compensated funeral costs data were available only for 2007, an average of these costs was applied to each death occurring in 2005 and 2006. It should be noted that this total amount includes all the funeral costs paid by the CSST, including those for six cases that were not identified as an occupational injury related death.

Table 3.2: Funeral costs associated with accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Compensated funeral costs	$469,180	-	-	$469,180
Uncompensated funeral costs	-	$432,776	-	$432,776
QPP death benefits	-	-	$447,500	$447,500
Total	**$469,180**	**$432,776**	**$447,500**	**$1,349,457**

3.3 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 the unworked (or non-productive) hours that employers nonetheless pay in the form of wages and employee benefits.

On the day of the accident, the employer is required to pay the 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 therefore 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.[7] These costs are estimated to be $9,436,618 for the accepted injuries occurring in one year (table 3.3).

Table 3.3: Salary costs associated with the accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Waste pay of the worker on the day of the accident	**$9,436,618**	**-**	**-**	**$9,436,618**

3.4 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 subsections, we describe the methods we used to arrive at these estimates.

3.4.1 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).[8] 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

[7] Employee benefits increase workers' compensation by 30% (see section 3.4.2 for more details).

[8] 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.

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: injuries with compensated days and fatal injuries. For the injuries with compensated days, 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:

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

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_n is the worker's annual pay at age n (includes wage growth adjustment);
- 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.[9] The probability of survival is taken from the life tables published by Statistics Canada (2006). Wage growth adjustment allows us to take into account the relationship between age and salary. Wage growth adjustment factors are estimated based on a similar approach as described in Biddle and Keane (2011).[10] The rate of increase of labour productivity was set at 1%.[11] Lastly, the discount rate used was 3% (see section 2.7).

The total lost wages resulting from workers' withdrawal from the labour market due to accepted injuries in one year amount to $922,589,623. This loss may be defined as equivalent to the lost production capacity for society. 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 (IRIs) and death benefits

[9] 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.

[10] The CSST database, which contains more than 360 000 cases on the 2005-07 period, was used to estimate the adjustment factors.

[11] According to a document published by the Institut de la statistique du Québec (ISQ, 2010), 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%.

paid to the employee and his family. The amount of the income replacement indemnities and death benefits paid by companies during the period under study totalled $526,053,094 and $13,922,646 respectively.[12] 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 $43,197,138. The total of the income replacement indemnities and death benefits assumed by the employers is thus $583,172,878.

Lost wages assumed by workers

For the worker, the lost wages correspond to the difference between his pay before and after the injury. During the indemnity period, these lost wages are measured as the difference between the income replacement indemnity that the worker received and his take-home pay. 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.[13] During the indemnity period, the workers 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 $63,250,026. However, they correspond to only a part of the lost wages assumed by workers during the indemnity period. There are, of course, 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.[14] Then, assuming an income tax rate of 50%, the loss of net earnings corresponds to 50% of the overage. These losses total $5,710,972. Thus, the total lost wages for workers during the indemnity period are $68,960,998.

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 found 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.[15]

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

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

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

[15] 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.

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 workers and assumed by the victims' families are estimated at $39,943,085. However, from that amount must be subtracted the death benefits received from the CSST. Thus, the lost wages assumed by the victims' families total $26,020,439.[16]

The total lost wages assumed by workers and their families are therefore $94,981,436 for the accepted injuries occurring in one year.

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, income replacement indemnities received by a 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. The worker is not penalized for not contributing to these plans and programs and retains his rights with respect to them. Thus, it is all the contributors to these plans and programs who have to absorb the related costs.

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 $229,582,481.

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 $39,943,085, 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 $14,852,828.

The total loss of income taxes and other deductions that the community has to assume is thus $244,435,309 for the accepted injuries occurring in one year.

3.4.2 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.

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

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).[17] 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%.

Statistics Canada (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. 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.

In this report, we estimate that, on average, employee benefits increase Québec workers' base pay by 30%, specifically 10% for mandatory employee benefits (excluding CSST contributions) and 20% for discretionary employee benefits.

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

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

By adding 30% in employee benefits (*EB*) for each injured worker, we obtain a loss of production capacity of $1,200,006,236, of which $277,416,613 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 3.3). 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 the contributors. However, we assume that most of the discretionary employee benefits

[17] 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.

continue to be paid during the indemnity period.[18] Applying a rate of 20%, the employee benefit costs paid by the employers for workers off work due to an occupational injury amount to $160,522,248[19] for the accepted injuries occurring in one year.

Employee benefit costs for workers

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 30%, 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 $16,438,773.

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 $13,069,778.

All told, the workers lose $29,508,552 in employee benefits due to the accepted occupational injuries that occur in one year in the 2005–2007 period.

Employee benefit costs for the community

During the period when the workers receive an income replacement indemnity, the employers do not have to pay of 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 at $87,385,813 for the accepted occupational injuries occurring in one year.

3.4.3 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,

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

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

> 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.[20]

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 $4,577,710 on average for the accepted injuries occurring in one year.

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:

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

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.

[20] For a more detailed definition of the opportunity cost approach and the replacement cost approach, see Lebeau and Duguay (2013).

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

The cost of non-productive household work due to death is estimated at $32,864,209.

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.[21] Accordingly, the household work cost for occupational injuries with compensated days is estimated at $271,743,418.

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 $300,029,916 for the accepted injuries occurring in one year. Table 3.4 presents a summary of the costs of the productivity losses.

Table 3.4: Productivity losses resulting from the accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Lost wages				
Income replacement (IRI + death benefits)	$583,172,878	-	-	$583,172,878
Lower earnings (net of compensation)	-	$94,981,436	-	$94,981,436
Income tax and other deductions	-	-	$244,435,309	$244,435,309
Employee benefits	$160,522,248	$29,508,552	$87,385,813	$277,416,613
Household work				
Compensated	$4,577,710	-	-	$4,577,710
Uncompensated	-	$300,029,916	-	$300,029,916
Total	**$748,272,836**	**$424,519,904**	**$331,821,122**	**$1,504,613,863**

3.5 Administrative costs

The administrative costs arising from a work accident may be many. It is difficult to accurately measure the scale of these costs because they are not usually included in corporate financial statements. The administrative costs that are estimated in this report are limited to turnover costs.

The main difficulty is to determine which injuries have resulted in a turnover. To identify these situations, several criteria were developed. These are:

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

- 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;[22]
- 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 3,019 turnovers for regular positions.

Assigning an average cost to turnover is no easy task. Turnovers usually include cost components that may be allowed for 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.

We assigned an employee turnover cost of 30%. This is the same percentage used in Lebeau et al. (2013). We believe it to be a minimum rate.

We estimate the cost of employee turnover attributable to the accepted occupational injuries occurring in one year to be $32,595,212, i.e. $10,798 per recruitment.[23] Table 3.5 presents a summary of the administrative costs, which are assumed by employers.

Table 3.5: Administrative costs associated with the accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Employee turnover costs (recruitment, training, etc.)	**$32,595,212**	**-**	**-**	**$32,595,212**

3.6 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

[22] 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.

[23] 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).

real. In fact, the CSST compensates the workers concerned for this type of cost (bodily injury indemnities).

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 an estimate of the value of a statistical life obtained using 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).[24]

The DALY (disability-adjusted life year) approach is complementary to the QALY approach. Instead of representing individuals' quality of life, it measures their disability[25], 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

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

[25] A DALY is equivalent to one year of life lost due to ill health.

year with the same health status (irrespective of age), the DALY measure assigns greater weight to the mid-life years and less weight to the early (childhood) and late (retirement) years. In other words, the individual's working years are more highly valued.

Figure 3.1, which is inspired by Robberstad (2005), 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.

We will carry out the analysis of the costs of occupational injuries in terms of DALYs.[26] 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.

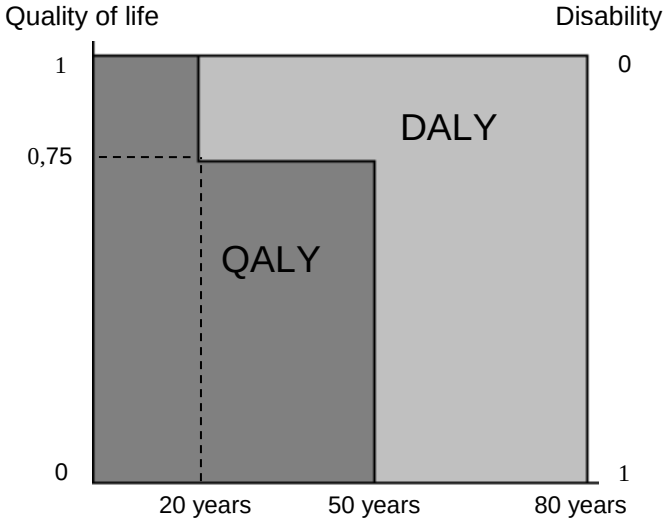

Figure 3.1: The complementarity of the QALY and DALY approaches: example of an individual with a 25% disability at age 20 and an early death at age 50

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:

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

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

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

agree on a certain form of discounting. Introducing a time preference, the two parts of equation (6) can be expressed as follows:

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

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

where

- 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;
- D is the weight assigned to the disability (between 0 and 1);
- e is Napier's constant (2.718…);
- r is the discount rate.

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.[27] 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 assign 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 life 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).[28] However, these tables do not constitute an exhaustive list of all possible injuries. It is therefore necessary to find in the 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,

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[27] This function takes the form $Cxe^{-\beta x}$, where C and β are constants and x is the age in years.

[28] http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf

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, 2010). 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. Human costs associated with temporary disabilities were not estimated in this study.[29]

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.[30]

Applying equation (9), we estimate that the occupational injuries that occur during one year in Québec result in an average of 21,603 DALYs. In other words, the equivalent of 21,603 years of life in good health is lost due to the occupational injuries that occur each year in Québec. This figure may appear high, but that is related to the fact that deaths and permanent disabilities have consequences that extend several years after the occurrence of the injury.

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 use the willingness-to-pay method.

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). The willingness-to-pay method is often used for estimating the value of a statistical life (VSL).[31]

Lebeau and Duguay (2013) 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 good 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.

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[29] We did not have the tools and data to properly estimate those costs. Although, based on tests made by the research team, we roughly estimate it would have increased human costs by around 1%.

[30] Some researchers claim that injuries may have consequences worse than death.

[31] See Lebeau and Duguay (2013) for more details about the methodological aspects of this method.

In this type of calculation, discounting is usually spread over 40 years because that is the approximate difference in workers' average (or median) 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).[32] Inserting this figure in equation (10) gives 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 opted for the MTQ value because our research suggests it is the only value 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 $69,419,261 annually.

Human costs for workers

Multiplying the number of DALYs by the VLY gives us the total costs borne by the workers, for cases resulting in death or permanent disability, namely $3,022,773,387.

To separate out the human costs, the total financial costs assumed by those workers have to be subtracted. By subtracting financial costs (funeral expenses, salary costs, employee benefits, household work) of $255,145,243, the human costs assumed by the workers and their families are estimated at $2,767,628,144 for all the accepted injuries occurring in one year.

It should be noted that, due to the methodology used to estimate the human costs, the bodily injury indemnities should not be subtracted from the total costs for the workers.[33] Thus, the total human costs are obtained by adding together the bodily injury indemnities and the human costs for the workers. Table 3.6 presents a summary of these costs, broken down by the party that assumes them.

[32] This value, which is used by the MTQ, is obtained using the willingness-to-pay method.

[33] The human costs for workers, which are estimated using the willingness-to-pay method, are already net of compensation.

Table 3.6: Human costs associated with the accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Bodily injury indemnities	$69,419,261	-	-	$69,419,261
Human costs net of compensation	-	$2,767,628,144	-	$2,767,628,144
Total	**$69,419,261**	**$2,767,628,144**	**-**	**$2,837,047,405**

4. ANALYSIS OF THE RESULTS

Table 4.1 presents the results of the estimation of the costs of occupational injuries in Québec for the 2005–2007 period.

Table 4.1: Costs associated with the accepted occupational injuries occurring in one year, Québec, 2005–2007

	Employers	Workers	Community	Total
Medical costs				
Medical aid costs	$213,746,031	-	-	$213,746,031
Rehabilitation costs	$22,144,046	-	-	$22,144,046
Total	**$235,890,077**	**-**	**-**	**$235,890,077**
Funeral costs				
Compensated funeral costs	$469,180	-	-	$469,180
Uncompensated funeral costs	-	$432,776	-	$432,776
QPP death benefits	-	-	$447,500	$447,500
Total	**$469,180**	**$432,776**	**$447,500**	**$1,349,457**
Salary costs				
Worker's waste pay on the day of the accident	**$9,436,618**	**-**	**-**	**$9,436,618**
Productivity losses				
Lost wages				
Indemnities (IRI + death benefits)	$583,172,878	-	-	$583,172,878
Drop in net earnings	-	$94,981,436	-	$94,981,436
Income tax and other deductions	-	-	$244,435,309	$244,435,309
Employee benefits	$160,522,248	$29,508,552	$87,385,813	$277,416,613
Household work				
Compensated household work	$4,577,710	-	-	$4,577,710
Uncompensated household work	-	$300,029,916	-	$300,029,916
Total	**$748,272,836**	**$424,519,904**	**$331,821,122**	**$1,504,613,863**
Administrative costs				
Employee turnover costs	**$32,595,212**	**-**	**-**	**$32,595,212**
Subtotal	**$1,026,663,923**	**$424,952,681**	**$332,268,622**	**$1,783,885,225**
Human costs				
Bodily injury indemnities	$69,419,261	-	-	$69,419,261
Human costs net of compensation	-	$2,767,628,144	-	$2,767,628,144
Total	**$69,419,261**	**$**2,767,628,144	**-**	**$2,837,047,405**
Total cost	**$1,096,083,184**	**$3,192,580,825**	**$332,268,622**	**$4,620,932,631**

4.1 Costs by cost component

Figure 4.1 charts the proportion of each component of the estimated costs.

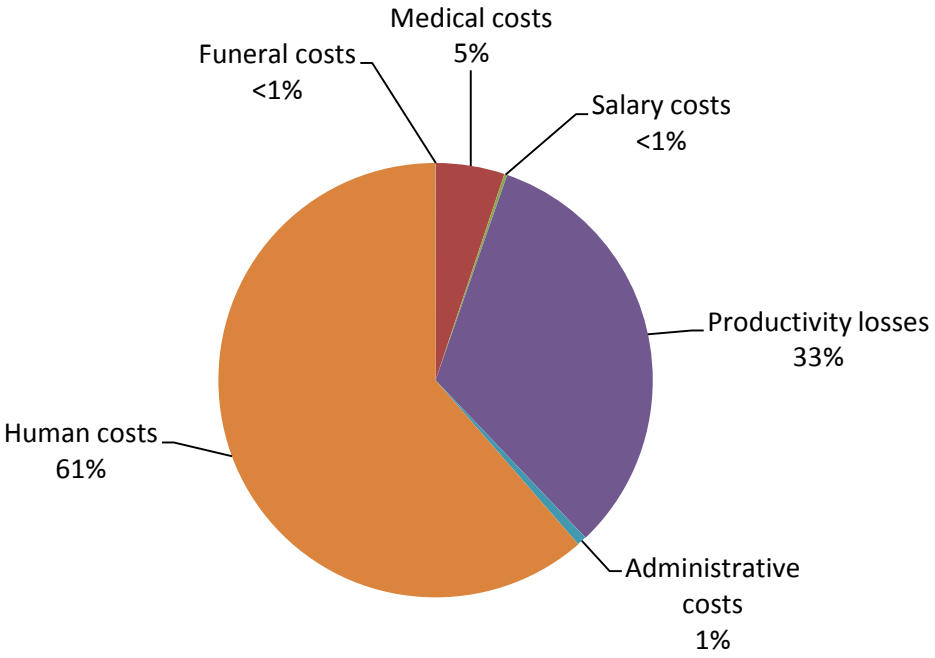

Figure 4.1: Costs of the accepted occupational injuries occurring in one year, Québec, 2005–2007

As can be seen, human costs (61%) and productivity losses (33%) together account for the vast majority of the costs of occupational injuries.

4.2 Costs by type of injury

Table 4.2 allows us to note, among other things, that the average cost of an occupational injury is estimated at $38,355 while that of a death is around $2.5 million.

Table 4.2: Costs of accepted injuries occurring in one year by type of injury, Québec, 2005–2007

Type of injury	Number of cases	%	Total cost per year	Average cost per case
Accident	115,300	95.70	$3,787,350,202	$32,848
Occupational disease	5,177	4.30	$833,582,429	$161,017
Total	120,477	100.00	$4,620,932,631	$38,355
Deaths	179	0.15	$448,886,791	$2,507,747
Accident-related deaths	102	0.08	$320,572,946	$3,142,872
Disease-related deaths	77	0.06	$128,313,845	$1,666,414

4.3 Costs by gender and occupational category

The costs of occupational injuries have also been analyzed by occupational categories (table 4.3):

- The injuries that affect men account for 70% of all accepted injuries;
- The average cost of the injury among men ($43,776) is higher than the average cost per case among women ($25,502);
- Approximately 71% of injured workers are in manual occupations;
- Injuries in manual occupations result in an average cost per injury of $41,117, which is higher than the average cost per injury in non-manual and mixed occupations ($34,716 and $29,968 respectively).

Table 4.3: Costs of the accepted injuries occurring in one year by gender and by occupational category, Québec, 2005–2007

Gender/occupational category	Number of cases	%	Total cost per year	Average cost per case
Male - Total	**84,741**	**70.3**	**$3,709,590,888**	**$43,776**
Manual occupation	68,688	57.0	$3,087,254,056	$44,946
Non-manual occupation	4,259	3.5	$195,022,867	$45,794
Mixed occupation	11,794	9.8	$427,313,966	$36,231
Female - Total	**35,736**	**29.7**	**$911,341,743**	**$25,502**
Manual occupation	17,098	14.2	$440,023,834	$25,735
Non-manual occupation	7,126	5.9	$200,198,693	$28,095
Mixed occupation	11,512	9.6	$271,119,216	$23,550
Male and female - Total	**120,477**	**100.0**	**$4,620,932,631**	**$38,355**
Manual occupation	85,787	71.2	$3,527,277,890	$41,117
Non-manual occupation	11,384	9.4	$395,221,559	$34,716
Mixed occupation	23,306	19.3	$698,433,182	$29,968

4.4 Costs by nature of injury

Table 4.4 presents the costs generated by the occupational injuries occurring in one year by the nature of the injury, in decreasing order of average cost.

- The most common natures of injury are sprains and strains (35.9%) and bruises and contusions (11.4%).
- Sprains and strains ($907 million) and fractures ($555 million) are the natures of injury that result in the highest costs per year.
- Disorders of the ear ($153,618) and multiple injuries ($117,034) result in the highest average cost per case.

Table 4.4: Costs of the accepted injuries occurring in one year by nature of injury, in decreasing order of average cost per case, Québec, 2005–2007

Nature of the injury	Annual number of cases	%	Time loss (days)	Total cost per year	Rank	Average cost per case	Rank
Disorders of the ear	2,420	2.0	72.3	$371,705,535	3	$153,618	1
Multiple injuries	2,892	2.4	101.0	$338,500,140	6	$117,034	2
Fractures	6,924	5.7	128.2	$555,042,921	2	$80,162	3
Mental disorders	1,377	1.1	227.7	$97,931,663	11	$71,102	4
Other injuries	963	0.8	52.3	$68,196,216	12	$70,792	5
Other diseases	5,535	4.6	94.7	$339,676,834	4	$61,373	6
Burns	2,272	1.9	28.7	$126,896,084	9	$55,852	7
Dorsopathies	2,936	2.4	122.0	$109,299,843	10	$37,232	8
Musculoskeletal disorders (except back disorders)	9,685	8.0	134.1	$328,866,397	7	$33,956	9
Open wounds	10,164	8.4	40.0	$339,645,444	5	$33,418	10
Pain (except back pain)	1,375	1.1	101.9	$42,852,530	13	$31,173	11
Sprain/strain	43,263	35.9	77.4	$906,776,239	1	$20,960	12
Surface wounds	1,643	1.4	27.3	$32,297,537	14	$19,654	13
Bruises, contusions	13,779	11.4	52.5	$244,288,609	8	$17,729	14
Disorders of the eye (conjunctivitis)	1,642	1.4	11.8	$13,819,066	15	$8,414	15
Foreign bodies	1,644	1.4	10.6	$9,952,654	16	$6,053	16
Subtotal	**108,515**	**90.1**	**80.2**	**$3,925,747,712**	**-**	**$36,177**	**-**
Unknown or uncoded	11,963	9.9	177.0	$695,184,919	-	$58,113	-
Total	**120,477**	**100.0**	**87.9**	**$4,620,932,631**	**-**	**$38,355**	**-**

Note: The average length, which corresponds to the average number of compensated days per injury, is based only on lost-time injuries.

4.5 Costs by event or exposure

Table 4.5 presents the costs resulting from the occupational injuries occurring in one year by event or exposure, in decreasing order of average cost per case.

- The most frequent events or exposures involve being struck by equipment or objects (11.3%) and same-level falls (10.9%).
- Falls on the same level, slips, trips ($416 million) and fall and jump to lower level ($386 million) are the events or exposures that result in the highest costs per year.
- Exposure to noise ($154,264) and transportation accidents ($125,163) result in the highest average cost per case.

Table 4.5: Costs of the accepted injuries occurring in one year by event or exposure, in decreasing order of average cost per case, Québec, 2005–2007

Event or exposure	Annual number of cases	%	Time loss (days)	Total cost per year	Rank	Average cost per case	Rank
Exposure to noise	2,402	2.0	84.7	$370,491,126	4	$154,264	1
Transportation accident	1,951	1.6	116.9	$244,234,112	9	$125,163	2
Exposure to harmful substances	2,642	2.2	73.1	$280,199,370	7	$106,069	3
Fall and jump to lower level	5,907	4.9	127.6	$385,573,706	2	$65,270	4
Caught or crushed	6,305	5.2	67.8	$330,023,372	5	$52,343	5
Contact with temperature extremes	1,904	1.6	23.7	$86,181,252	15	$45,263	6
Violent acts	2,165	1.8	156.4	$97,848,907	14	$45,196	7
Repetitive motion	2,751	2.3	164.2	$108,704,531	13	$39,519	8
Other NEC or UNS event or exposure	7,764	6.4	87.6	$268,233,189	8	$34,548	9
Fall on the same level, slip, trip	13,150	10.9	90.4	$415,626,324	1	$31,606	10
Struck by	13,599	11.3	53.8	$383,864,194	3	$28,228	11
Other overexertion	12,761	10.6	86.6	$287,604,709	6	$22,537	12
Struck against	7,468	6.2	48.6	$163,666,722	12	$21,917	13
Overexertion in lifting	9,624	8.0	86.4	$210,621,260	10	$21,884	14
Other bodily reactions	9,648	8.0	78.7	$204,378,202	11	$21,183	15
Rubbed-abraded-friction	2,197	1.8	45.4	$44,657,312	17	$20,323	16
Bending-climbing-reaching	4,598	3.8	66.9	$80,805,612	16	$17,575	17
Foreign bodies	2,348	1.9	9.6	$13,032,175	18	$5,551	18
Subtotal	**109,184**	**90.6**	**80.5**	**$3,975,746,076**	**-**	**$36,413**	**-**
Unknown or uncoded event or exposure	11,294	9.4	178.7	$645,186,555	-	$57,128	-
Total	**120,477**	**100.0**	**87.9**	**$4,620,932,631**	**-**	**$38,355**	**-**

Note: The average length, which corresponds to the average number of compensated days per injury, is based only on lost-time injuries. The acronyms NEC and UNS stand for “not elsewhere classified” and “unspecified” respectively.

4.6 Costs by source of injury

Table 4.6 presents the costs of the occupational injuries occurring in one year by source of injury, in decreasing order of average cost per case.

- More than one injury in four (28.5%) is related to bodily motion or position.
- Bodily movement or position ($851 million) and ground and indoor surfaces ($391 million) are the sources that result in the highest costs per year.
- Noise ($154,395) and plants, animals, and minerals ($108,924) result in the highest average cost per case.

Table 4.6: Costs of the accepted injuries occurring in one year by source of injury, in decreasing order of average cost per case, Québec, 2005–2007

Source	Annual number of cases	%	Time loss (days)	Total cost per year	Rank	Average cost per case	Rank
Noise	2,398	2.0	82.9	$370,291,550	3	$154,395	1
Plants, animals, and minerals	2,533	2.1	72.7	$275,940,071	4	$108,924	2
Highway vehicles, motorized	1,940	1.6	107.3	$207,313,644	7	$106,881	3
Machinery	3,882	3.2	81.6	$251,157,517	5	$64,692	4
Other vehicles	1,496	1.2	89.9	$90,135,932	13	$60,251	5
Machine, tool, and electric parts	1,941	1.6	72.9	$104,656,631	11	$53,919	6
Ground and indoor surfaces	8,167	6.8	109.7	$390,683,720	2	$47,839	7
Other work structures or surfaces	3,499	2.9	93.8	$148,123,817	8	$42,329	8
Hand tools – powered	1,009	0.8	58.9	$42,147,523	21	$41,772	9
Other building materials	486	0.4	68.9	$19,148,555	26	$39,400	10
Chemicals and chemical products	2,030	1.7	42.6	$78,532,739	15	$38,692	11
Other sources	2,500	2.1	57.8	$93,945,208	12	$37,573	12
Wood, lumber	1,429	1.2	73.4	$48,725,240	20	$34,097	13
Structural metal materials	2,121	1.8	65.1	$64,441,242	16	$30,387	14
Stairs	1,643	1.4	92.5	$48,974,541	19	$29,814	15
Other parts and materials	7,548	6.3	65.0	$224,912,477	6	$29,796	16
Bodily motion or position	34,310	28.5	88.3	$851,003,726	1	$24,803	17
Other parts and materials	3,272	2.7	55.0	$79,056,518	14	$24,159	18
Other containers	5,234	4.3	77.2	$125,489,761	10	$23,977	19
Persons	6,284	5.2	99.3	$145,720,902	9	$23,189	20
Furniture	2,681	2.2	71.2	$55,987,140	18	$20,883	21
Other hand tools – nonpowered	1,335	1.1	55.9	$27,725,241	23	$20,773	22
Hand truck, dolly	1,069	0.9	63.4	$20,962,959	25	$19,616	23
Boxes, crates and cartons	3,631	3.0	77.0	$63,533,021	17	$17,499	24
Cutting hand tools – nonpowered	2,267	1.9	26.0	$37,506,118	22	$16,542	25
Scrap, waste, debris	2,324	1.9	18.1	$26,527,915	24	$11,416	26
Subtotal	**107,028**	**88.8**	**80.4**	**$3,892,643,708**	**-**	**$36,370**	**-**
Unknown or uncoded source	13,449	11.2	161.4	$728,288,923	-	$54,152	-
Total	**120,477**	**100.0**	**87.9**	**$4,620,932,631**	**-**	**$38,355**	**-**

Note: The average length, which corresponds to the average number of compensated days per injury, is based only on lost-time injuries.

4.7 Costs by injured body part

Table 4.7 presents the costs generated by the injuries occurring in one year by injured body part, in decreasing order of average cost per case.

- The two body parts most frequently injured are the back (24.9%) and the hands and fingers (15.5%).
- The back ($672 million) and multiple body parts ($611 million) are the body parts that generate the highest costs per year.
- The ear ($152,433) and the chest ($104,044) result in the highest average cost per case.

Table 4.7: Cost of the accepted injuries occurring in one year by body part, in decreasing order of average cost per case, Québec, 2005–2007

Body part	Annual number of cases	%	Time loss (days)	Total cost per year	Rank	Average cost per case	Rank
Ear	2,912	2.4	67.3	$443,883,476	4	$152,433	1
Chest	2,800	2.3	64.0	$291,358,459	6	$104,044	2
Multiple body parts	6,200	5.1	147.4	$610,729,041	2	$98,499	3
Other lower extremities	3,251	2.7	82.0	$175,156,427	9	$53,878	4
Other upper extremities	3,980	3.3	97.4	$199,973,246	8	$50,249	5
Shoulder	8,656	7.2	150.7	$393,204,738	5	$45,426	6
Body systems	3,473	2.9	153.2	$155,811,310	10	$44,859	7
Knee	6,439	5.3	110.8	$260,195,393	7	$40,407	8
Head	3,467	2.9	48.4	$138,297,224	12	$39,890	9
Trunk-abdomen-groin	2,086	1.7	86.4	$82,837,278	16	$39,705	10
Wrist	4,400	3.7	104.5	$153,376,338	11	$34,856	11
Elbow	3,407	2.8	126.5	$110,600,993	15	$32,466	12
Foot/toe(s)	4,106	3.4	56.7	$114,921,534	14	$27,989	13
Hand/finger(s)	18,685	15.5	49.0	$501,172,067	3	$26,822	14
Cervical vertebrae	3,257	2.7	91.3	$81,476,870	17	$25,016	15
Ankle	5,582	4.6	58.5	$129,581,879	13	$23,213	16
Back	30,003	24.9	87.4	$672,254,307	1	$22,406	17
Eye	4,114	3.4	13.4	$45,007,978	18	$10,940	18
Prostheses	2,819	2.3	44.6	$2,670,340	19	$947	19
Subtotal	**119,638**	**99.3**	**87.6**	**$4,562,508,896**	**-**	**$38,136**	**-**
Other body parts (unknown)	839	0.7	127.4	$58,423,735	-	$69,635	-
Total	**120,477**	**100.0**	**87.9**	**$4,620,932,631**	**-**	**$38,355**	**-**

Note: The average length, which corresponds to the average number of compensated days per injury, is based only on lost-time injuries.

4.8 Costs by industry

Table 4.8 presents the costs of occupational injuries by industry and by occupational category, in decreasing order of costs per full-time equivalent (FTE) worker. The variable corresponds to the total costs divided by the number of FTE workers. An FTE worker is equivalent to 2,000 hours worked per year.

- The injuries occurring in one year result, on average, in costs estimated at $1,712 per FTE worker.
- The 26 target groups, whose costs-per-FTE indicator is more than twice as high as the average, account for around 44% of all costs of accepted occupational injuries in Québec but only 13% of the total number of FTE workers. Among the industries/occupational categories heading the list, 23 involve manual workers and three mixed workers.
- The industries with the highest costs per FTE worker are: mining except oil and gas extraction ($15,043, though only for manual workers); support activities for mining and oil and gas extraction ($10,282); waste management and remediation services ($10,070); speciality trade contractors and telecommunications ($8,758); non-metallic mineral product manufacturing ($8,578); and support activities for agriculture and forestry ($7,576).

Table 4.8: Cost of the accepted occupational injuries that occurred in one year by industry and occupational category, in decreasing order of cost per FTE worker, Québec, 2005–2007

Industry	Occ. cat.	FTE paid workers	Annual number of injuries	Time loss (days)	Total costs per year	Average cost per injury	Average cost per FTE	Rank
Mining (except oil and gas)	Man.	5,928	1,001	172.7	$89,177,743	$89,118	$15,043	1
Support activities for mining and oil and gas extraction	Man.	1,640	150	211.7	$16,863,081	$112,171	$10,282	2
Waste management and remediation services	Man.	2,658	684	83.9	$26,765,531	$39,112	$10,070	3
Specialty trade contractors; Telecommunications	Man.	56,399	6,185	145.6	$493,939,933	$79,861	$8,758	4
Non-metallic mineral product manufacturing	Man.	7,336	1,323	81.4	$62,924,880	$47,562	$8,578	5
Support activities for agriculture and forestry	Man.	2,310	430	127.5	$17,500,006	$40,698	$7,576	6
Forestry and logging	Man.	5,510	291	211.9	$40,846,068	$140,525	$7,413	7
Petroleum product wholesaler-distributors	Man.	1,034	132	127.0	$7,040,023	$53,199	$6,809	8
Local, municipal, and regional public administration	Man.	10,625	2,601	63.9	$67,534,197	$25,965	$6,356	9
Forestry and logging	Mixed	1,592	92	173.2	$9,289,116	$101,336	$5,835	10
Provincial and territorial public administration	Man.	1,842	339	64.4	$10,738,156	$31,707	$5,830	11
Fishing, hunting, and trapping	Man.	1,038	37	-	$5,987,281	$161,818	$5,768	12
Building material and garden equipment and supplies dealers	Man.	4,333	871	70.7	$24,888,440	$28,564	$5,744	13
Truck transportation	Man.	40,678	3,114	130.1	$215,656,485	$69,261	$5,302	14
Construction of buildings; Heavy and civil engineering construction	Man.	29,415	1,928	145.7	$154,415,223	$80,105	$5,250	15
Wood product manufacturing; Furniture and related product manufacturing	Man.	47,208	6,197	79.4	$247,004,180	$39,861	$5,232	16
Rental and leasing services	Man.	2,246	259	99.9	$11,719,308	$45,248	$5,218	17
Plastics and rubber products manufacturing	Man.	17,983	2,982	75.5	$86,690,369	$29,074	$4,821	18
Primary metal manufacturing	Man.	16,420	2,068	61.2	$77,867,064	$37,653	$4,742	19
Food manufacturing; Beverage and tobacco product manufacturing	Man.	34,293	5,996	72.5	$152,242,578	$25,391	$4,439	20
Management of companies and enterprises; Credit intermediation and related activities; Securities, commodity contracts, and other financial investment and related activities; Funds and other financial vehicles	Mixed	1,204	93	153.6	$5,162,438	$55,312	$4,288	21
Support activities for agriculture and forestry	Mixed	968	74	163.2	$4,045,794	$54,428	$4,180	22
Amusement, gambling, and recreation industry; Performing arts, spectator sports, and related industries; Motion picture and sound recording industries; Heritage institutions	Man.	5,744	637	103.9	$22,863,008	$35,873	$3,980	23
Administrative and support services; Real estate	Man.	31,173	3,241	107.6	$123,500,628	$38,106	$3,962	24
Paper manufacturing	Man.	16,476	1,350	80.8	$62,363,990	$46,207	$3,785	25
Personal and laundry services	Man.	3,766	332	98.6	$13,431,821	$40,498	$3,567	26
Subtotal		**349,819**	**42,406**	**101.2**	**$2,050,457,340**	**$48,353**	**$5,861**	
Subtotal/total (%)		**12.9**	**35.2**		**44.4**			
Total		**2,708,596**	**120,477**	**87.9**	**$4,620,932,631**	**$38,355**	**$1,712**	

Note: The selected groups have costs per FTE at least twice as high as the Québec average. Calculation of the average time loss, which corresponds to the average number of compensated days per injury, is based on lost-time injuries only. The average compensation periods were not calculated when an industry had fewer than 100 lost-time injuries during the three years under study. Groups of workers comprising fewer than 500 FTE workers have been excluded from this table. Mixed transportation workers have also been excluded due to a matching problem between the Statistics Canada data and the CSST's.

4.9 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 4.2 illustrates this phenomenon. The figure plots the total cost of occupational injuries against the percentage of the most costly injuries. As can be seen, the most costly 10% of injuries alone account for 85% of the total cost ($3.9 billion) and the most costly 20% injuries are responsible for 94% of the total cost ($4.4 billion).

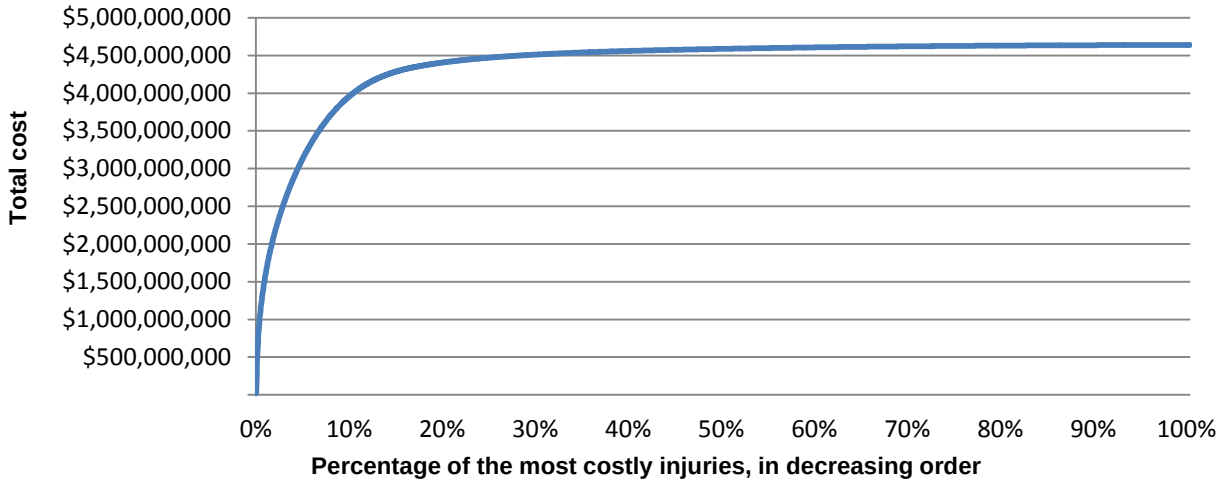

Figure 4.2: Impact of the most costly injuries on the total cost of occupational injuries, Québec, 2005–2007

5. 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.

5.1 Unestimated costs components

The cost components not estimated in this report can be grouped into two categories. First, the cost components for which the data are not available. Several cost components require corporate data that can be obtained only by requesting them from the corporations concerned. It is therefore not possible to adequately estimate these costs using the data currently available to us. Second, those that cannot be estimated specifically for each injury. Some costs can be estimated overall but not individually, based on the specifics of each injury. Assigning the same average costs to each of the injuries would not have made a significant contribution to the analysis.

Table 5.1 summarizes the cost components that have not been estimated in this study.

Table 5.1: Costs not estimated in this study by exclusion criteria

Data unavailable
▪ First aid (employer) ▪ Waste pay of other employees on the day of the accident ▪ Waste pay of the injured worker on his return (presenteeism) ▪ Waste pay while on temporary assignment ▪ Lost wages due to a change in career path ▪ Overtime ▪ Accident file-related administrative costs ▪ Legal costs ▪ Transportation of the injured worker ▪ Property damage ▪ Reputation ▪ Human costs (co-workers, temporary disability)
Costs not specific to individual injuries
▪ CSST administrative costs ▪ Cost of the occupational injury administrative tribunal (Commission des lésions professionnelles) ▪ Use of public services

5.2 Available data

Three limitations apply to using data taken from the CSST's administrative records. First, these data concern only injuries reported to the insurer (the CSST), which is a subset of all the injuries that occur in the workplace. A Canadian study (Shannon and Lowe, 2002) estimates that 40% of eligible injuries are underreported to provincial occupational injury compensation boards. As a result, this component tends to underestimate the "true" cost of occupational injuries. However, that 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.[34] This means that the data used do not include disbursements that occurred after the maturity period.[35] 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. 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. Obviously, then, 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. To improve the estimates made in this report, it would be relevant to use the CSST's disbursements with an average maturity of more than three years. To do so, an analysis of the changes in these disbursements over a sufficiently long period would make it possible to develop a projection method. Such a method could be used to obtain a more complete picture of the costs of injuries assumed by employers.

Third, the gross pay of the injured workers, as obtained from CSST records, tends 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 pay figures obtained from CSST records therefore result in both an underestimate and an overestimate of the wages lost by the workers.[36]

5.3 Sensitivity analysis

Because the estimates in this report are made using several models and assumptions, 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 occupational injuries (table 5.2). 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.

Table 5.2: 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	$2,532,734,789	$6,271,036,960
Discount rate (r)	1% - 5%	$4,462,260,189	$4,771,980,702

[34] 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.

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

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

5.4 Human costs

Despite all 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 made in Québec, we have opted for the value used by the Québec transportation department (MTQ), i.e. $3,234,381 (2006).[37]

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 5.2, the choice of VSL has a significant impact on the total cost estimates. A similar approach is used in table 5.3, which presents the financial costs and human costs for three different VSLs.

Table 5.3: 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	$1,783,885,225	$748,849,564	$2,532,734,789
$3,234,381	$1,783,885,225	$2,837,047,405	$4,620,932,631
$5,000,000	$1,783,885,225	$4,487,151,734	$6,271,036,960

We note that human costs are relatively low or high 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).

Using permanent physical and mental impairment (PPMI) in estimating 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 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.[38]

Moreover, the PPMI rate is determined using a bodily injury scale that is not necessarily comparable with what is done in other countries and provinces. Thus, even when using a methodology similar to that found in other studies, it is not possible to adequately compare our

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

[38] However, as the bias so created is positive for some injuries and negative for others, part of the bias should be cancelled out.

estimates with those of other studies. However, as the IRSST is seeking to use the economic indicators to compare groups of workers and types of injury for Québec only, this limitation is not very limiting.

5.5 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 costs method (Koopmanschap et al., 1995). That method holds that the full employment hypothesis advanced by the human capital method is unsustainable in the reality of the labour market.[39]

The friction costs 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.

As Leigh (2011) notes, the friction costs method requires unemployment rate data by region, occupation, and industry, which are very difficult to obtain. We do not have access to that type of data. This limitation partly explains why relatively few studies in the scientific literature use this method, compared with the very widely used human capital method.

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

In addition, as Johannesson and Karlsson (1997) mention, there is no assurance that an injured worker will be replaced by an unemployed person. For example, the 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.

As Leigh (2011) notes, the friction costs method is probably a method more applicable to cost calculations at the company level than at the societal level.

6. CONCLUSION

Studies on the costs of occupational injuries in Québec are quite rare. The few Québec studies retained limit themselves to estimating the costs assumed by the companies. This study innovates by estimating the overall costs—human as well as financial—of occupational injuries.

The annual costs of accepted occupational injuries are estimated at approximately $4.62 billion on average for the 2005–2007 period. Of this amount, approximately $1.78 billion is allocated to financial costs and $2.84 billion to human costs. The average cost of an occupational injury totals $38,355. Due to the limitations described in this study, this is likely an underestimation of the costs.

Analysis of the results makes it possible to identify the types of injury and the industries with the highest costs. We note, among other things, that injuries resulting from exposure to noise are those with the highest average costs. However, limiting the analysis to more traditional indicators, such as frequency and duration, the impacts of this type of injury appear less pronounced. Thus, in some circumstances, taking into account the costs of injuries casts a new and complementary light on the traditional indicators.

When the costs are analyzed by industry, topping the list are the main industries of the priority groups targeted by the CSST (e.g. mining, forest products, construction). There are also industries that are not among the main priority groups (e.g. waste management and remediation services). To a large extent, these results agree with those obtained using the more traditional indicators developed and produced at the IRSST.

The economic indicator developed in this study has several advantages. First, it constitutes a measure of the overall impact of occupational injuries, taking into account their consequences for employers, workers, and the community. Second, the consequences of occupational injuries resulting in death are better measured than by using a frequency indicator, where death is considered only an additional event, or a severity indicator based on the number of compensated days. Actually, one of the main advantages of this economic indicator is that it allows several indicators to be integrated into a single indicator. For example, the number of injuries, number of compensated days, PPMI rate, fatalities, and compensated medical costs are all indicators that have an impact on the estimated costs of occupational injuries.

Despite its many advantages, the economic indicator proposed here remains relatively complex to produce. Although it provides an overview of the financial impact of occupational injuries, it does not make it possible to perform more specific analyses or to identify the industries with, say, the greatest risk of occupational injury or the injuries that result in the largest average number of CSST-compensated days. In this sense, the economic indicators are complementary to the traditional indicators.

Thus, this study allows the magnitude of the costs resulting from occupational injuries in Québec to be better understood. These indicators should be used as a complement to other indicators and sources of information for determining occupational health and safety research directions and for prevention.

BIBLIOGRAPHY

Access Economics (2006). *The economic and social costs of occupational disease and injury in New Zealand*, NOHSAC, Technical Report 4, Wellington.

Bellavance, F., Dionne, G., Lebeau, M. (2009). *The Value of a Statistical Life: A Meta-Analysis with a Mixed Effects Regression Model*, Journal of Health Economics, 28(2), 444-464.

Biddle, E., Keane, P. (2011). *The Economic Burden of Occupational Injuries to Civilian Workers in the United States, 1992-2002*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS.

Chandler, W. (1994). *The Value of Household Work in Canada, 1992*, National Income and Expenditure Accounts: Quarterly Estimates, Statistics Canada, Ottawa, Canada.

Commission de la santé et de la sécurité du travail du Québec (2010). *Statistiques annuelles 2009*, 156 p.

Commission de la santé et de la sécurité du travail du Québec (2011). *Rapport annuel de gestion 2010*, 168 p.

Corso, P., Finkelstein, E., Miller, T., Fiebelkorn, I., Zaloshnja, E. (2006). *Incidence and lifetime costs of injuries in the United States*, Injury Prevention, 12, p. 212-218.

Dionne, G., Lanoie, P. (2004). *Public Choice about the Value of a Statistical Life: The Case of Road Safety*, Journal of Transport Economics and Policy, 38(2), p. 247-274.

Duguay, P., Boucher, A., Busque, M.-A., Prud'homme, P., Vergara, D. (2012). *Lésions professionnelles indemnisées au Québec en 2005–2007 : Profil statistique par industrie – catégorie professionnelle*, Études et recherches / Rapport R-749, Montréal, IRSST, 176 p.

Goodchild, M., Sanderson, K., Nana, G. (2002). *Measuring the total cost of injury in New Zealand: a review of alternative cost methodologies Report to The Department of Labour: BERL#4171*. Business and Economic Research Limited.

Gosselin, M. (2004). *Analyse des avantages et des coûts de la santé et de la sécurité au travail en entreprise - Développement de l'outil d'analyse*, Études et recherches / Rapport R-375, Montréal, IRSST, 68 p.

Hamdad, M. (2003). *Valuing Households' Unpaid Work: Comparisons between 1992 and 1998*, Technical working paper. Income and Expenditure Accounts Division, Statistics Canada.

Hawrylyshyn, O. (1978). *Estimating the Value of Household Work in Canada, 1971*, Catalogue No. 13-558.

Health and Safety Executive (1999). *The Cost to Britain of Workplace Accidents and Work-Realted Ill Health in 1995/96*, Health and Safety Executive, 133 p.

Hensler, D.R., Marquis, M.S., Abrahams, A.F., Berry, S.H., Ebener, P.A., Lewis, E.G., Ling, E.A., MacCoun, R.J., Manning, W.G., Rogowski, J.A., Vaiana, M.E. (1991). *Compensation For Accidental Injuries In The United States*, Report R-3999-HHS/ICJ, RAND: Santa Monica, CA.
Hodgson, T.A., Meiners, M. (1982). *Cost-of-illness methodology: a guide to current practices and procedures*, Milbank Memorial Fund Quarterly Journal, 60(3), p. 429-62.

Institut de la statistique du Québec (2009). *L'annuaire Québécois des statistiques du travail. Portrait des conditions et de la dynamique du travail, volume 5, numéro 2, édition 2009*, 245 p.

Institut de la statistique du Québec (2010). *Indicateurs de suivi de la Stratégie gouvernementale de développement durable 2008-2013*, 109 p.

Jelsma, J., Shumba, D., Hansen, K., Weerdt, W.D., Cock, P.D. (2002). *Préférences des Zimbabwéens vivant en zone urbaine concernant la valeur de la santé et de la vie en fonction de l'âge*, Bulletin de l'Organisation mondiale de la Santé, Recueil d'articles N° 7.

Johannesson, M., Karlsson, G. (1997). *The friction cost method: A Comment*, Journal of Health Economics, 16, p. 249-255.

Kniesner, T.J., Viscusi, W.K., Wook, C., Ziliak, J.P. (2007). *Pinning down the value of statistical life*, Working Paper IZA No. 3107, 32 p.

Koopmanschap, M.A., Rutten, F.F., van Ineveld, B.M., van Roijen, L. (1995). *The friction cost method for measuring indirect costs of disease*, Journal of Health Economics, 14(2), p. 171-189.

Lawrence, B.A., Bhattacharya, S., Zaloshnja, E., Jones, P., Miller, T.R., Corso, P.S. (2009). *Medical and work loss cost estimation methods for the WISQARS cost of injury module*, Calverton, MD: CDC.

Lebeau, M., Duguay, P. (2013). *The Costs of Occupational Injuries – A review of the Literature*, Studies and Research Projects / Report R-787, Montréal, IRSST, 85 p.

Lebeau, M., Duguay, P., Boucher, A. (2013). *Estimating the Costs of Occupational Injuries – A Feasibility Study in the Mining Industry*, Studies and Research Projects / Report R-774, Montréal, IRSST, 90 p.

Leigh, J.P., Markowitz, S.B., Fahs, M., Landrigan, P. (2000). *Costs of occupational injuries and illnesses*, Ann Arbor, MI: University of Michigan Press, 310 p.

Leigh, J.P. (2011). *Economic burden of occupational injury and illness in the United States*, The Milbank Quarterly, 89(4), p. 728-772.

Mathers, C.D., Lopez, A.D., Murray, C.J.L. (2006). *The burden of disease and mortality by condition: Data, methods, and results for 2001*, In: Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL, eds. *Global burden of disease and risk factors*. Washington, DC/New York, NY: The World Bank/Oxford University Press.

Miller, T.R., Galbraith, M. (1995). *Estimating the costs of occupational injury in the United States*, Accident Analysis and Prevention, 27(6), p. 741-747.

Ministère des Transports du Québec (2007). *Guide de l'analyse avantages-coûts des projets publics en transport*; *Partie 3 - Paramètres (valeurs de 2006)*, 13 p.

Murray, C.J.L. et Lopez, A.D. (1996). *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Vol. 1 of *Global Burden of Disease and Injury Series*. Cambridge, MA: Harvard University Press.

Montmarquette, C., Scott, I. (2007). *Le taux d'actualisation pour l'évaluation des investissements publics au Québec*, Centre interuniversitaire de recherche en analyse des organisations.

O'Connell, M. et Kung, M.-C. (2007). *The Cost of Employee Turnover*, Industrial Management. 14 p.

Organisation mondiale de la Santé (2001). *Consommation d'alcool*, Aide mémoire N^{o}349, <http://www.who.int/mediacentre/factsheets/fs349/fr/index.html> (Réf. du 6 mai 2011).

Rice, D.P., MacKenzie, E.J. and Associates (1989). *Cost of Injury in the United States: A Report to Congress, 1989*, San Francisco, CA: Institute for Health & Aging, University of California and Injury Prevention Center, The Johns Hopkins University.

Richardson, J. (2002). *Age weighting and time discounting: technical imperative versus social choice*, Chapter 13.2, p. 663-676 dans Murray, C.J.L., Salomon, J.A., Mathers, C.D., Lopez, A.D., *Summary Measures of Population Health: Concepts, Ethics, Measurement and Applications*, World Health Organization, Geneva.

Robberstad, B. (2005). *QALYs vs DALYs vs LYs Gained: What are the Differences, and What Difference do They Make for Health Care Priority Setting?* Norsk Epidemiologi, 15 (2), p. 183-191.

Shannon, H.S., Lowe, G.S. (2002). *How many injured workers do not file claims for workers' compensation benefits?*, American journal of industrial medicine, 42, p. 467-473.

Statistics Canada (2003). *Perspectives on Labour and Income*, 4(5), 26 p.

Statistique Canada (2006). *Life Tables, Canada, Provinces and Territories – 2000 to 2002*, catalogue No. 84-537-XIE.

Statistics Canada (2010). *Unpaid Housewok by Person* [online], <http://www.statcan.gc.ca/concepts/definitions/unpaid-impaye01-eng.htm> (March 3, 2011).

Transport Canada (2008). *Estimates of the Full Cost of Transportation in Canada*, Ottawa, Canada.

Treasury Board of Canada Secretariat (2007). *Canadian Cost-Benefit Analysis Guide – Regulatory Proposals*, Ottawa.

U.S. Department of Transportation (2009). *Revision of Departmental Guidance on Treatment of the Value of Life and Injuries*, Office of the Assistant Secretary for Transportation Policy.

Waehrer, G.M., Dong, X.S., Millera, T., Haile, E., Men, Y. (2007). *Costs of occupational injuries in construction in the United States*, Accident Analysis & Prevention, 39(6), p. 1258-1266.

Weil, D. (2001). *Valuing the economic consequences of work injury and illness: a comparison of methods and findings*, American Journal of Industrial Medicine, 40(4), p. 418-437.