Early Detection of High-Risk Claims at the Workers’ Compensation Board of British Columbia

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We developed a combined decision-analysis and logistic-regression approach for identifying high-risk claims at the Workers’ Compensation Board of British Columbia (WCB). The early detection of such claims and subsequent intervention is likely to reduce their eventual cost and to speed up worker rehabilitation. High-risk claims are extremely costly to the WCB; for the approximately 321,000 short-term disability claims with injury dates between 1989 and 1992, high-risk claims accounted for $1.2 billion (64 percent) of the total payment of $1.8 billion, even though they constituted only 4.2 percent of the claims. We developed separate logistic regression models for each injury type. We found that the age of worker and number of workdays lost were predictive of high-risk status. We used decision analysis to develop a classification rule that has high out-of-sample predictive power. The WCB has incorporated these results in a claims-profiling scorecard, which identifies claims needing early intervention. We estimate that our method saves the WCB $4.7 million annually.

T
he Workers’ Compensation Board of British Columbia (WCB) is a statutory agency responsible for the occupational health and safety, rehabilitation, and compensation interests of British Columbia’s workers and employers. Created in 1917, the WCB’s main objective is to help workers and employers to create and maintain safe workplaces and to ensure injured workers secure income and safe return to work. The WCB obtains the funds to make compensation payments and meet its other financial obligations from assessments levied on employers. In return, employers receive protection from lawsuits arising from work-related injuries and diseases. For waiving the right to sue, injured workers receive the right to benefits on a no-fault basis. In 2002, the WCB served more than 165,000 employers who employed about 1.8 million workers in British Columbia and spent over $1 billion (all figures in Canadian dollars) on compensation and rehabilitation.

The main objective of our study was to develop a systematic approach to identifying short-term disability (STD) claims that pose a potentially high financial risk to the WCB. We refer to these claims as high-risk claims. We anticipated that by detecting high-risk claims early and subsequently intervening, the WCB would both improve claims management and reduce future costs associated with these claims. To discriminate between high-risk and low-risk claims, we...
combined decision analysis with logistic regression. Logistic-regression models use claim characteristics to assign a probability that a claim becomes high risk. Claims with sufficiently high probabilities are candidates for intensive claim-management intervention. We used decision-analytic methods to determine a threshold or cutoff point above which a claim is classified as high risk.

Logistic regression, although not as widely used as linear regression, has been used in a variety of business and medical applications in which the goal was to find models that separate data into two groups. For example, Wiginton (1980) used logistic regression in credit scoring. The model allowed classification of credit applicants into high- and low-credit-risk groups. In a similar context, Johnson (1998) developed a logistic regression model to determine whether or not college students should be given credit for future purchases at a campus department store. Thompson (1985) used logistic regression to study outcomes in a community mental health program, while Lemeshow et al. (1988) determined factors affecting the probability of patients surviving to hospital discharge after admission to an intensive care unit.

Recently, WCB managers have become increasingly aware that they could use quantitative tools to identify high-risk claims. Two unpublished internal studies motivated our research. Jessup and Gallie (1996) identified age of worker, gender, and nature of injury as factors that can be used for profiling high-risk claims, but they did not develop a model to quantify the risk associated with them. Fattedad and Charron (1999) studied the WCB’s inventory of high-risk claims and concluded that a claim that exceeds 70 workdays lost is likely to become high risk.

Claim Processing at the WCB

A request for compensation from an injured worker for an injury or illness sustained at work is referred to as a claim. Whenever a claim corresponding to an injury or illness resulting from a person’s employment causes temporary absence from work, the claim is referred to as a short-term disability claim or simply an STD claim. For STD claims, the WCB provides wage-loss payments for the workdays lost (STD days paid) and pays for the cost of hospitalization, treatment, prescription drugs, and necessary medical appliances. The vast majority (96 percent) of injured workers with STD claims recover from their injuries and return to work within a few months.

Whenever a worker fails to recover completely from a work-related injury or illness and is left with a permanent partial disability or permanent total disability, the WCB ends the STD status of the claim and begins paying permanent disability benefits. Permanent disability benefits are called long-term disability or LTD benefits. Once an STD claim receives LTD benefits, it is no longer classified as an STD claim but as an LTD claim. If a worker incurs a permanent total disability, the WCB awards a periodic payment equal to 75 percent of his or her estimated average earnings for life. A worker who incurs permanent partial disability returns to work after his or her medical condition becomes fairly stable. In this case, the compensation is a periodic payment of 75 percent of the estimated loss of average earnings resulting from the impairment and is payable for life.

The estimated loss of earnings is positively correlated with the percentage of disability—a quantity determined by the WCB’s health-care professionals based on the physical condition of the worker. Generally, the lower the percentage of disability the less the estimated loss of earnings. To reduce the cost of LTD claims, claim managers and rehabilitation specialists focus on reducing the percentage of disability through early detection and intensive intervention; Head (1995) gives more details. For example, a lower-back-strain claim that may have resulted in a 25 percent permanent disability without early intervention may be reduced to a 10 percent disability through intensive early treatment and rehabilitative efforts.

Converted and Nonconverted STD Claims

We refer to the transition of STD claims into LTD claims as conversion. STD claims that become LTD claims are called converted STD claims. Conversely, STD claims that result in the injured workers’ returning to work are called nonconverted STD claims. We assumed it would be beneficial to detect potential
LTD claims early in their life cycles. To this end, we developed logistic regression models to detect STD claims that have a high likelihood of converting.

The sample we used to investigate the conversion of STD claims consisted of all 320,973 STD claims that had injury dates between January 1, 1989 and December 31, 1992. We chose this time period to reduce any bias that could have resulted from including claims with more recent injury dates because roughly eight percent of STD claims that convert require over five years to do so.

To assess the financial impact, we captured all payments these claims received up to July 1999. Our investigation revealed that although converted STD claims represented only 4.2 percent of all STD claims, they accounted for 64.3 percent ($1,173 million) of the total payments of $1,824 million. On the other hand, nonconverted STD claims represented 95.8 percent of all claims in the sample but incurred only 35.7 percent of the costs. Thus, from a financial point of view, we viewed converted STD claims as high-risk claims, whereas we categorized nonconverted STD claims as low-risk claims. In addition, the $86,000 average cost of converted claims is 41 times greater than the average cost of $2,100 for nonconverted claims. These costs vary by injury type.

### Classification of STD Claims by Injury Type

The WCB uses the nature of injury (NOI) to classify injuries or illnesses in terms of their principal physical characteristics (Table 1). Ten of the most frequently observed injury types made up 95.7 percent of all claims in our sample.

The conversion rate (CR) is the proportion of STD claims that convert. Although the overall CR is 4.2 percent, it varies from 0.5 percent for scratches and abrasions to 83.3 percent for amputations or enucleations. The CR is a key indicator of the severity of the injury type. The WCB now uses it to compare the extent of conversion within different subsets of claims.

Within each injury-type group, the average cost of converted STD claims is 12 to 195 times higher than the average cost of nonconverted STD claims.

### Data Sources and Collection

We extracted data for this study from the WCB data warehouse—a single integrated source of information developed in the late 1990s by combining data from many different department and service databases.

<table>
<thead>
<tr>
<th>Nature of Injury</th>
<th>Number of STD Claims and the Corresponding Percentage of All Claims (%)</th>
<th>Number of Converted STD Claims and the Corresponding Percentage of All Converted Claims (%)</th>
<th>Conversion Rate (%)</th>
<th>Average Cost of Nonconverted Claims ($)</th>
<th>Average Cost of Converted Claims ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprains, strains</td>
<td>159,100 (49.6)</td>
<td>5,059 (37.4)</td>
<td>3.2</td>
<td>2,395</td>
<td>106,066</td>
</tr>
<tr>
<td>Contusion, crushing, bruise (soft tissue)</td>
<td>50,717 (15.8)</td>
<td>1,395 (10.3)</td>
<td>2.8</td>
<td>1,587</td>
<td>99,666</td>
</tr>
<tr>
<td>Cut, laceration, puncture (open wound)</td>
<td>44,234 (13.8)</td>
<td>1,846 (13.7)</td>
<td>4.2</td>
<td>1,073</td>
<td>40,827</td>
</tr>
<tr>
<td>Fracture</td>
<td>16,163 (5.0)</td>
<td>2,557 (18.9)</td>
<td>15.8</td>
<td>4,047</td>
<td>80,982</td>
</tr>
<tr>
<td>Scratches, abrasions (superficial wound)</td>
<td>11,596 (3.6)</td>
<td>62 (0.5)</td>
<td>0.5</td>
<td>487</td>
<td>94,801</td>
</tr>
<tr>
<td>Tenosynovitis, synovitis, tendonitis</td>
<td>11,096 (3.5)</td>
<td>641 (4.7)</td>
<td>5.8</td>
<td>2,604</td>
<td>88,857</td>
</tr>
<tr>
<td>Burn or scald (heat or hot substances)</td>
<td>7,095 (2.2)</td>
<td>141 (1.0)</td>
<td>2.0</td>
<td>967</td>
<td>62,216</td>
</tr>
<tr>
<td>Bursitis (epicondylitis of tennis elbow)</td>
<td>4,884 (1.5)</td>
<td>383 (2.8)</td>
<td>7.8</td>
<td>3,752</td>
<td>72,271</td>
</tr>
<tr>
<td>Carpal tunnel syndrome</td>
<td>1,706 (0.5)</td>
<td>197 (1.5)</td>
<td>11.5</td>
<td>6,017</td>
<td>69,016</td>
</tr>
<tr>
<td>Amputation, enucleation</td>
<td>699 (0.2)</td>
<td>582 (4.3)</td>
<td>83.3</td>
<td>3,311</td>
<td>41,220</td>
</tr>
<tr>
<td>Other injury types</td>
<td>13,683 (4.3)</td>
<td>649 (4.8)</td>
<td>4.7</td>
<td>2,496</td>
<td>106,958</td>
</tr>
<tr>
<td>All injury types</td>
<td>320,973 (100)</td>
<td>13,512 (100)</td>
<td>4.2</td>
<td>2,101</td>
<td>86,223</td>
</tr>
</tbody>
</table>

Table 1: We show the distribution of short-term disability (STD) claims and converted STD claims by nature of injury, the corresponding conversion rates, and the average costs of converted (to long-term disability benefits) and nonconverted claims. The conversion rate is the proportion of STD claims that become long-term disability claims. (All costs are in 1991 Canadian dollars.)
It is updated monthly. We used Crystal Reports to access and extract data from the data warehouse and SPSS to perform statistical analyses. The information extracted included injury date, age of the injured worker on the date of injury, gender of the injured worker, payment dates, monthly payments, number of STD days paid, nature of injury, and injured body part.

Logistic Regression

Regression models relate a response variable to one or more predictor variables. In logistic regression, the response variable is binary, while in the linear regression model, it is continuous and unbounded. Associated with each claim in our study are a binary response variable $Y$ and $p$ predictor variables, which we denote by the vector $x = (x_1, x_2, \ldots, x_p)$. The condition $Y = 1$ represents a converted STD claim, and $Y = 0$ represents a nonconverted STD claim. Denote by $\pi(x) = P(Y = 1 | x)$ the conditional probability that $Y = 1$ for a predictor variable vector with values $x$. The probability that the response variable equals 0 is $P(Y = 0 | x) = 1 - \pi(x)$. The odds favoring $Y = 1$ over $Y = 0$ are given by $O(Y = 1 | x) = \pi(x)/[1 - \pi(x)]$. The logit transformation ($L$) expresses the odds of conversion on the natural logarithm scale as $L(x) = \ln[O(Y = 1 | x)]$.

Logistic regression models represent the logit $L$ as a linear function of the predictor variables as follows:

$$L(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p,$$

where $\beta_0, \beta_1, \ldots, \beta_p$ are the parameters of the model. For application, we convert logits to probabilities with the equation $\pi(x) = e^{L(x)}/[1 + e^{L(x)}]$.

We estimated the parameters of the logistic regression using maximum likelihood (Hosmer and Lemeshow 1989, McCullagh and Nelder 1989). Most statistical software packages include maximum likelihood estimation and model diagnostic measures. The diagnostics we used include the Wald test to assess the significance of model parameters, the deviance and Hosmer-Lemeshow tests to assess overall significance, and residual and influence analyses to determine the effects of individual data points on the parameter estimates. An additional decision-focused criterion for evaluating model quality is the correct classification rate, that is, the proportion of observations that are classified correctly using model estimates of $\pi(x)$. The implementation of this measure requires specification of a cutoff point or a value of $P(Y = 1 | x)$ above which an observation is classified as 1 based on its predictor values and the estimated parameters. In most applications, analysts use a default value of 0.5, but this choice ignores the consequences of incorrect decisions (McCullagh and Nelder 1989, Neter et al. 1996, Ryan 1996).

Logistic Regression Model Development

The predictor variables we considered for analysis were nature of injury, industry of worker, gender, age of worker, STD days paid, and injured body part. Several of these variables were categorical with multiple levels. An aggregate model including all of these variables together with first-order interactions would have required hundreds of predictor variables. We felt that such a large model would have been difficult to interpret, analyze, and apply. Further, it would have been difficult to reliably estimate parameters for this combined model given the large data set. Instead, we chose to stratify data on the basis of the nature of injury and develop separate models for the 10 most frequent injury types. We did consider, however, using a finer stratification based on cross-classifying injured body part and nature of injury. The cross-classification would have resulted in over 200 models to assess and analyze, for which we did not have time. Moreover, over 120 of these categories had too few claims for reliable estimates of the parameters of the logistic-regression models.

Further, at this stage of analysis, we chose not to incorporate all of the potential predictors in our model because of unavailability of data. Gender of claimant might have proved to be a significant predictor, but initial examination of the data set showed that 68 percent of the cases were missing this information. Moreover, restricting the analysis to cases that included gender of claimant would have biased the analysis because only the most severe claims were coded for gender. On the other hand, all claims from
our sample had information regarding the injured worker’s age and the number of STD days paid. Consequently, after stratifying the claims on the basis of nature of injury, we used two quantitative variables to predict the conversion of STD claims; the claimant’s age (AGE), and the number of STD days paid (DAYS). The resulting model had the form:

\[ L(\text{AGE}, \text{DAYS}) = \beta_0 + \beta_1 \text{AGE} + \beta_2 \text{DAYS}. \]

An aggregate model with different slopes for AGE and DAYS within each injury category would require 30 parameters. We decided it would be easier to estimate, apply, and justify separate models for each injury type (Table 2).

All models include DAYS and AGE as significant (at the 0.10 level) predictors except those for scratches and abrasions, burns, and carpal tunnel syndrome for which only DAYS is significant. We chose not to develop a regression model for amputations and enucleations because of the extremely high conversion rate (83.3 percent) for injuries of this type; we classified all claims within this category as high risk.

<table>
<thead>
<tr>
<th>Model</th>
<th>Intercept</th>
<th>DAYS</th>
<th>AGE</th>
<th>Nature of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprain or strain</td>
<td>−5.7373</td>
<td>0.0197</td>
<td>0.0311</td>
<td>Sprains, strains</td>
</tr>
<tr>
<td>Contusion</td>
<td>−5.5536</td>
<td>0.0247</td>
<td>0.0236</td>
<td>Contusion, crushing, bruise (soft tissue)</td>
</tr>
<tr>
<td>Laceration</td>
<td>−4.8297</td>
<td>0.0473</td>
<td>0.0124</td>
<td>Cut, laceration, puncture (open wound)</td>
</tr>
<tr>
<td>Fracture</td>
<td>−3.6756</td>
<td>0.0212</td>
<td>0.0088</td>
<td>Fracture</td>
</tr>
<tr>
<td>Abrasion</td>
<td>−6.1125</td>
<td>0.0528</td>
<td>—</td>
<td>Scratches, abrasions (superficial wound)</td>
</tr>
<tr>
<td>Joint inflammation</td>
<td>−4.6126</td>
<td>0.0172</td>
<td>0.0224</td>
<td>Tenosynovitis, synovitis, tendinitis</td>
</tr>
<tr>
<td>Burn</td>
<td>−5.1627</td>
<td>0.0455</td>
<td>—</td>
<td>Burn or scald (heat or hot substances)</td>
</tr>
<tr>
<td>Bursitis</td>
<td>−3.7105</td>
<td>0.0138</td>
<td>0.0103</td>
<td>Bursitis (epicondylitis or tennis elbow)</td>
</tr>
<tr>
<td>Carpal tunnel</td>
<td>−2.9705</td>
<td>0.0109</td>
<td>—</td>
<td>Carpal tunnel syndrome</td>
</tr>
<tr>
<td>Amputation</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Amputation, enucleation</td>
</tr>
<tr>
<td>Other</td>
<td>−4.1689</td>
<td>0.0153</td>
<td>0.0150</td>
<td>Other injury types</td>
</tr>
</tbody>
</table>

Table 2: We show model descriptions and estimated parameters of the logistic regression models. The abrasion, burn, and carpal tunnel models have only DAYS paid as predictor. The amputation model is not based on logistic regression; the conversion rate for this model is so high that all claims within this category are classified as high risk.

Using the estimates of the parameters of the models, we calculate estimates of the probability of conversion for each claim (Figure 1) by substituting the parameter estimates into the equation

\[ \pi(x) = \frac{e^{\beta_0 + \beta_1 \text{AGE} + \beta_2 \text{DAYS}}}{1 + e^{\beta_0 + \beta_1 \text{AGE} + \beta_2 \text{DAYS}}}. \]

Quantifying this relationship improved the WCB’s claims management methodology.

**Claim Classification**

Our goal was to link the logistic regression models to the decision to classify a claim as high risk. We sought a cutoff point on the probability of conversion that would allow the WCB to classify a claim as either high risk or low risk. Any claim with an estimated probability of conversion equal to or exceeding the cutoff point is classified as a high-risk claim, while any claim that has an estimated probability of conversion below the cutoff value is classified as a low-risk claim.

Prior to this study, the WCB used a cutoff point of 85 STD days paid for all claims regardless of the nature of injury and the age of injured worker, even though Fattedad and Charron (1999) noted that 70 STD days would have been preferable. It classified any claim with over 85 STD days paid as high risk. The major drawback of this approach was its very low accuracy in identifying converted claims. By using the 85 STD days paid cutoff point within our sample, we classified only 7,538 (55.8 percent) of the 13,512 converted claims correctly. On the other hand, using the same cutoff point, we correctly classified 295,409 (96.1 percent) of the nonconverted claims. Even though the overall classification error was less than six percent (we misclassified only 18,026 claims using this rule), the high error rate (44.2 percent) in the most costly case (classifying a high-risk claim as low risk) clearly indicated the need for an improved approach.

**Decision Analytic Approach**

The managerial decision problem is to classify claims as high risk or low risk based on their probability of conversion. A simple decision tree (Figure 2) represents the problem a claim manager faces once a cutoff
Figure 1: We show the estimated probabilities of conversion for claimants with sprains or strains as a function of the number of STD days paid and age of claimant. The greater the number of STD days paid and the older the injured worker, the higher the probability of conversion.

Figure 2: We use a decision tree to classify claims as high risk or low risk. $C_{\text{Interv}}$ represents the average per-claim cost of early intervention. It includes the costs for extra claim management and care. $C_{\text{Nonconv}}$ represents the average cost of claims that do not convert (to long-term disability benefits). $C_{\text{Conv/HR}}$ represents the average cost of claims classified as high risk that subsequently convert, while $C_{\text{Conv/LR}}$ represents the average cost of claims classified as low risk that convert. The difference ($C_{\text{Conv/LR}} - C_{\text{Conv/HR}}$) represents that component of the average cost that early intervention may prevent; it exceeds $C_{\text{Interv}}$. 
point for separating high-risk and low-risk claims has been specified.

The managerial objective is to minimize the expected total cost of claims to the WCB. If the estimated probability of conversion for a claim is higher or equal to a cutoff probability \( P \), the claim manager should classify it as high risk and intervene. If the estimated probability for the claim is less than \( P \), the claim manager should classify it as low risk and not intervene. The decision analyst’s role is to choose the cutoff point \( P \) from a continuum of possible values that affect the probabilities of classifying the two claim types correctly. The analysts’ decision problem can be represented by a decision tree in which choosing a cutoff point precedes the claim-classification decision.

The quantities \( C_{\text{Interv}} \), \( C_{\text{Nonconv}} \), \( C_{\text{Conv|HR}} \), and \( C_{\text{Conv|LR}} \) represent the average costs associated with each decision and outcome and vary among injury types. The quantity \( C_{\text{Interv}} \) represents the average per-claim cost of early intervention. It includes the costs for extra claim management and care. The quantity \( C_{\text{Nonconv}} \) represents the average cost of claims that do not convert. The quantity \( C_{\text{Conv|HR}} \) represents the average cost of claims classified as high risk that subsequently convert. \( C_{\text{Conv|LR}} \) represents the average cost of claims classified as low risk that convert. The difference \( (C_{\text{Conv|LR}} - C_{\text{Conv|HR}}) \) represents that component of the average cost that early intervention may prevent. Our data shows that it exceeds \( C_{\text{Interv}} \). These costs may vary with claim characteristics other than injury type, but we did not pursue this issue. Thus, a claim manager wishes to avoid two errors; intervening when not necessary and incurring an extra cost of \( C_{\text{Interv}} \), and not intervening when necessary and incurring a cost of \( (C_{\text{Conv|LR}} - C_{\text{Conv|HR}}) \).

Let \( EC(P|x) \) denote the expected cost for an individual claim associated with the decision rule that is based on a cutoff point \( P \) for a claim with characteristics \( x \). This cost is given by

\[
EC(P|x) = (C_{\text{Interv}} + C_{\text{Conv|HR}}) \times \Pr(\text{claim is classified as high risk and converts}|x)
\]

\[
+ (C_{\text{Interv}} + C_{\text{Nonconv}}) \times \Pr(\text{claim is classified as high risk and does not convert}|x)
\]

\[
+ C_{\text{Conv|LR}} \times \Pr(\text{claim is classified as low risk and converts}|x)
\]

\[
+ C_{\text{Nonconv}} \times \Pr(\text{claim is classified as low risk and does not convert}|x).
\]

Because all the probabilities vary with claim characteristics, to determine the expected cost of using cutoff point \( P \) for the whole inventory of claims, we must sum this cost over the distribution of claims with different characteristics. The expected total cost \( ETC(P) \) is

\[
ETC(P) = (C_{\text{Interv}} + C_{\text{Conv|HR}}) \times N_{\text{Conv|HR}}(P)
\]

\[
+ C_{\text{Conv|LR}} \times N_{\text{Conv|LR}}(P)
\]

\[
+ (C_{\text{Interv}} + C_{\text{Nonconv}}) \times N_{\text{Nonconv|HR}}(P)
\]

\[
+ C_{\text{Nonconv}} \times N_{\text{Nonconv|LR}}(P),
\]

where for each cutoff point \( P \),

\[
N_{\text{Conv|HR}}(P) = \text{number of claims that converted and were classified as high risk},
\]

\[
N_{\text{Conv|LR}}(P) = \text{number of claims that converted but were classified as low risk},
\]

\[
N_{\text{Nonconv|HR}}(P) = \text{number of claims that did not convert but were classified as high risk},
\]

\[
N_{\text{Nonconv|LR}}(P) = \text{number of claims that did not convert and were classified as low risk}.
\]

Using estimates of \( C_{\text{Conv|HR}} \), \( C_{\text{Interv}} \), \( C_{\text{Conv|LR}} \), and \( C_{\text{Conv|LR}} \), we evaluated \( ETC(P) \) for various values of \( P \) using historical data and determined the optimal cutoff point by minimizing \( ETC(P) \) with respect to \( P \). \( C_{\text{Nonconv}} \) represents the average cost of nonconverted claims (Table 1). On the other hand, estimating the values of \( C_{\text{Interv}} \), \( C_{\text{Conv|HR}} \), and \( C_{\text{Conv|LR}} \) was difficult and required a new way of thinking about claim-management costs. Prior to this study, WCB management did not explicitly evaluate these costs. To estimate the values of \( C_{\text{Conv|HR}} \) and \( C_{\text{Conv|LR}} \), we used the average costs of converted claims (Table 1) as reference points. Because these costs resulted from using a cutoff point of 85 STD days paid, we denoted them by \( C_{\text{Conv|85}} \). If claim managers had not intervened early
for any of the converted claims, the WCB would have incurred an average cost per converted claim of $C_{\text{Conv/LR}}$ that would be greater than $C_{\text{Conv/85}}$. Conversely, if claim managers had intervened early for all converted claims, the WCB would have incurred an average cost per converted claim of $C_{\text{Conv/HR}}$ that would be lower than $C_{\text{Conv/85}}$. To estimate the values of $C_{\text{Conv/LR}}$ and $C_{\text{Conv/HR}}$, we used $C_{\text{Conv/85}}$ as a reference point and adjusted it based on expert knowledge within the organization regarding various cost components of converted claims (Table 3). We set $C_{\text{Interv}}$ equal to a common value of $1,000 for each injury type. We estimated this amount by taking into account the average intervention time and the average cost of other resources, such as the medical examination and treatment required for rehabilitating the injured worker.

We used a simple search procedure to determine the optimal cutoff point. We calculated $\text{ETC}(P)$ for various values of $P$ and identified that value of $P$ that minimized $\text{ETC}(P)$ (Table 3). To our knowledge, this is the only study that provides a formal method for combining logistic regression with decision analysis.

### Model Accuracy

To assess the accuracy of the models, we determined their rates of correct classification using the optimal cutoff points within the sample and with a different data set. We evaluated the percentages of claims correctly classified for the 1989–1992 claims data, which we used in developing our model (Table 4). Most of the models were highly accurate; eight out of 11 have over 80 percent overall accuracy. They were more accurate in predicting nonconverted claims than converted claims with six out of the 11 strata having over 90 percent accuracy. They were fairly accurate in predicting converted claims; eight out of 11 models had over 70 percent accuracy.

The final step of the model-building process was cross-validation. We investigated the model’s performance on a set of data that contained all 77,815 STD claims with injury dates in 1993. We used the logistic regression models to predict the likely outcome (converted or nonconverted) of all claims from the cross-validation set. For each model, we used the optimal cutoff point of the 1989–1992 data set (Table 3). The percentages of claims correctly classified in the cross-validation sample are very similar to the percentages of claims correctly classified in the 1989–1992 sample. These results provide strong support for using the logistic regression models for claim classification.

### Critical Number of STD Days Paid

Claim managers found it easier and more intuitive to make decisions based on claim characteristics rather than cutoff probabilities. Consequently, we translated the optimal cutoff point on the probability scale into critical values of the predictor variables incorporated into the models. Because the logistic regression models explicitly incorporated age and number of STD days paid and implicitly involved nature of injury, for each case (claim with a specific age and injury type), we transformed the cutoff point on the probability scale to a cutoff point on the number-of-STD-days-paid scale for different ages. We refer to this as the critical number of STD days paid.

A claim is high risk as soon as the number of STD days paid equals or exceeds the critical level. For example, the optimal cutoff point of 0.094 for fracture claims translates into a critical number of 50 STD days paid for a 40-year-old claimant (not the 85 days the WCB traditionally used for all claims) (Table 5).
In practice, we use a table that provides the critical number of STD days for every age between 18 and 65. For most combinations of age and injury type, the critical level is substantially below 85 days. For all injuries for which we incorporated age as a predictor, the value of the critical number of STD days paid decreases as age increases. This means that the WCB should intervene sooner for older claimants. On the other hand, for abrasions, burns, and carpal tunnel syndrome, for which we did not include age as a predictor, the critical number of STD days does not vary with age.

Estimated Savings

To estimate savings from using our decision-analytic approach, we first calculated \( ETC(P) \) on the basis of the old practice of using 85 STD days paid as the cutoff point. We then computed \( ETC(P) \) using the optimal cutoff points (Table 3) and evaluated the difference between the two costs (Table 6). Under the classification scheme we proposed, many more converted claims were classified as high risk in each category.

The greatest savings occur for lacerations, sprains and strains, amputations, contusions, and fractures. The reductions in costs mainly derive from three sources. One is the cost difference \( C_{\text{Con}(LR)} - C_{\text{Con}(HR)} \): the greater the difference between the cost of converted claims classified as low risk and the cost of converted claims classified as high risk, the greater the savings (Table 3). A second factor affecting savings is the difference between our model’s critical number of STD days and the 85 STD days previously used, that is, the greater the difference the greater the savings.
We estimated that the WCB would save $15.3 million over four years by implementing the proposed method, or approximately $3.8 million annually (1991 value). This represents about $4.7 million in September 2002 dollars (adjusted using the British Columbia consumer price index).

### Implementation

The compensation services division of the WCB administers STD claims and is responsible for determining a worker’s rights to compensation and the amount of benefits awarded. To implement our results, the compensation services division developed a claim-profiling scorecard. The scorecard includes several quantitative and qualitative measures that are indicators of whether a claim is likely to become high risk. These measures were categorized as primary or secondary. The only primary measure is the age- and injury-type-dependent critical number of STD days paid (Table 5). Secondary measures include severity of injury, expected recovery time of over 12 weeks, prior injury or pre-existing condition in the area of the body where the injury occurred, and whether or not the claimant had previous claims with the WCB.

Several of the secondary measures may not be known in the early stages of claim processing. Consequently, if the number of STD days paid on a claim exceeds the age- and injury-dependent critical value, the WCB classifies the claim as high risk regardless of the status of the secondary measures.

In a pilot study, one of the WCB's area offices used this system for more than four months at the beginning of 2000. Because the pilot study showed that under the new system the office processed claims in a more cost-effective way than it had previously, the WCB now uses it in all its offices and has incorporated it into the compensation services division’s computer-based claims-management system to automate the process.

The new scorecard system has greatly improved the WCB’s processing of STD claims. It helps the WCB to use its adjudication staff more efficiently. First-level adjudicators working in the call center continue to deal with simple, straightforward claims, but they send claims classified as high-risk to the next...
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adjudication level (claim managers) as soon as they identify them.

Conclusion

Early identification of potentially high-risk claims is crucial for any workers’ compensation board because it can then improve claims management, provide early preventive intervention that is likely to reduce future costs, and return claimants to work sooner.

The implementation of this new method has considerably improved the practice of claims management at the WCB. An immediate and unanticipated benefit is that the WCB has fewer claims in the queue waiting to be processed because it identifies high-risk claims earlier. The biggest advantage for the WCB of this approach is reduced claims costs because of its appropriate early intervention; about $4.7 million per year. Further, we anticipate that more injured workers will return to work sooner than in the past. This conservative estimate does not include the increased contribution of workers returning to the workforce sooner and does not account for the possibility that managed claims do not eventually convert. As a result of this study, the WCB increasingly accepts and adopts statistical and operations research methods for improving all aspects of its operations.

In the next step of our study, we will focus on determining whether we should incorporate other predictors into the logistic regression models to improve their prediction accuracy. Predictors that we might consider are gender, injured body part, and worker’s industry. Model recalibration will be ongoing.

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Ralph W. McGinn, P. Eng., President and CEO, Workers’ Compensation Board of British Columbia, P.O. Box 5350, Station Terminal, Vancouver, British Columbia, Canada V6B 5L5, writes: “This letter is to confirm the implementation of the method of early detection of high-risk claims at the Workers’ Compensation Board (WCB) of British Columbia, described in the article, ‘Early Detection of High-Risk Claims at the Workers’ Compensation Board of British Columbia.’

“During the past few years the WCB has become increasingly involved in developing quantitative tools for improving its business decision making. This process was catalyzed by the implementation of our data warehouse that gave our staff the opportunity to access detailed information on more than 3 million claims. The ‘Early Detection of High-Risk Claims’ project is one of the major achievements for the research staff of our organization, and the ‘critical short-term disability days’ provided by the study are being used in the Compensation Services division in a ‘claim profiling’ scorecard to early detect and manage high-risk claims.”
“The method of early detection of high-risk claims has considerably improved the practice of claims management at the WCB. The immediate impact is that we have fewer claims in the queue (waiting to be processed) since potentially high-risk claims are identified earlier. In the longer term, we expect that the early intervention on high-risk claims will reduce their average cost by $2,000–$3,000 and return workers to their place of employment sooner. The quantifiable savings for the WCB are difficult to determine at this time, as the effects of using the new method cannot be fully measured since the new WCB claims management system needs a warm-up period. We expect, however, annual savings of millions of dollars as a result of the implementation of the new method.”