

1999 Young Investigator Research Award Winner

Prognostic Factors for Time Receiving Workers' Compensation Benefits in a Cohort of Patients With Low Back Pain

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Study Design. Prospective inception cohort study.

Objective. To develop a prognostic model that predicts time receiving workers' compensation benefits for low back pain claimants.

Summary of Background Data. As the cost and difficulty of managing low back pain escalate, any predictor of outcome is advantageous.

Methods. To obtain the outcome and predictor variables, patient data from two separate databases were linked: a clinical database and an administrative (Ontario workers' compensation) database. Claimants injured between January 1 and December 31, 1994, were included and observed for 1 year from the date of accident. The outcome variable was cumulative number of calendar days receiving benefits.

Results. Multivariable Cox proportional hazards regression (forward stepwise) showed eight significant predictors; five were associated with increased time receiving benefits compared with their reference groups: 1) working in the construction industry, 2) older age, 3) lag time from injury to treatment, 4) pain referred into the leg, and 5) three or more positive Waddell nonorganic signs. Three predictors were associated with reduced time receiving benefits: 1) higher values of questionnaire score, 2) intermittent pain, and 3) a previous episode of back pain. A predictive score was calculated to categorize claimants as at high or low risk for chronicity. When an arbitrary cutoff point was set at the 75th percentile of predictive score, negative predictive value was 94%.

Conclusion. This research identified eight factors for time receiving workers' compensation benefits among claimants with low back pain. This model discriminates between high- and low-risk claimants. Few low-risk claimants continued to receive benefits for more than 3 months. [Key words: back pain, Cox regression, inception, prognosis, workers' compensation] *Spine* 2000;25:147-157

As the cost and complexity of managing low back pain escalate, and all opportunities for primary and secondary prevention of disability are seized, any predictor of outcome is advantageous. Most people with occupational low back pain recover quickly.²⁰ Yet, predicting future chronic cases, shortly after symptom onset, is valuable, because this group accounts for a disproportionate fraction of the associated costs; the 7.4% of Quebec patients

with low back pain lasting longer than 6 months in 1981 accounted for 73% of the medical costs and 76% of compensation and indemnity payments.^{1,52} The Quebec Task Force on Spinal Disorders⁵⁷ concluded that, "Prognosis has become a matter of opinion and not of fact. Accordingly, the prudent clinician should be conscious of the need to identify, as early as possible, factors likely to lead to chronic distress and chronic functional disability. Research into these factors is essential if management strategies are to succeed."

The purpose of this study was to develop and validate a prognostic model, using survival analysis methods that predicts time that patients with low back pain received workers' compensation benefits. The research question was: Using patient information collected from a clinical database and manually linked with variables from an administrative (workers' compensation) database, what are key predictors of time receiving benefits in this occupationally injured cohort?

■ Methods

Study Design. In this prospective prognosis study, an inception cohort of 2007 Ontario Workers' Safety & Insurance Board (WSIB)—formerly WCB—claimants was analyzed. To obtain an inception cohort, subjects were sought once they became accepted lost-time claimants, reported for rehabilitation and were observed for 1 year after the accident date. Inclusion criteria focused on claimants who began treatment in a rehabilitation program while in the acute or subacute stage.^{17,20} Chronic cases were omitted to avoid developing a model based on cases in which the outcome had already occurred and thereby biasing the prediction of chronicity.^{3,3} Those with a previous history of spine surgery were excluded. Table 1 lists the inclusion criteria.

To obtain the outcome and predictor variables, patient data from two separate databases were linked. The clinical database, from the Canadian Back Institute (CBI), contained patient data for routinely collected variables, obtained by either physiotherapy assessment or patients' self-reports. The administrative database, from the WSIB Corporate Data Services, contains injured workers' lost-time claims information. The claim number was the common field in both databases and allowed for linkage between the two. The WSIB database is the best single source of information on work-related injuries in Ontario; however, similar to many administrative databases, it lacks the clinical detail desirable for epidemiologic research.⁴ Therefore, linkage with the clinical database provided an opportunity to enrich this investigation of claims-based data.

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Table 1. Patient Inclusion Criteria

Received Workplace Safety & Insurance Board (WSIB) lost time benefits for a work injury (accepted claim)
Injured between January 1, 1994 and December 31, 1994
Assessed for primary complaint of low back pain at any one of the 20 physiotherapy clinics in Ontario
No history of spine surgery
Less than 91 days between reported WSIB injury date (first day of lost time) and first day of physiotherapy treatment

Variables. Twenty-four explanatory variables were analyzed from both databases. To assist with multivariable analysis, the explanatory variables were grouped into three clusters⁸: clinical (15 variables), sociodemographic (8 variables), and a low back pain questionnaire (1 variable). Tables 2 and 3 display the frequency distributions and descriptive statistics for these independent variables.

The questionnaire responses were analyzed as a single variable, the total score for 18 patient self-report items based on a previously published instrument, the Low Back Outcome Score.²⁴ The questionnaire was modified for use in this study to include other important questions (such as mechanism of injury, litigation, and smoking status) as determined by two of the authors (GM, HH; Appendix A). The scoring of the complete questionnaire resulted in a minimum score of 6 and a maximum of 100. The higher the score, the greater the perceived level of function.

The outcome variable was cumulative number of calendar days that a claimant received benefits for 1 year from the date of accident. Cumulative time receiving benefits was not measured beyond 1 year after accident. This reflects WSIB's administrative policy of routinely examining claims that have not closed at 1 year, after which a complex adjudication process for wage replacement begins, related to permanent disability awards. That is, claimants may move from temporary total and/or temporary partial benefits to longer-term payments.

Sample Size. Of the 2007 claimants, administrative data from WSIB records were not available for 23 patients. This reduced the sample size to 1984. There were 1326 of the 2007 patients (66.1%) who completed the entire questionnaire; 330 (16.4%) did not answer one of the questions, 119 (5.9%) missed two questions, and 232 (11.6%) missed more than two. Questionnaire scores were proportionally rescaled for those who missed one or two items ($n = 449$) and were included with the completed questionnaires to allow for data analysis that included as many patients as possible ($n = 1775$; 88%). The 12% who missed more than two questions were excluded from the analysis ($n = 232$). Thus, the final sample size for analysis including questionnaire data was 1752 (or 87% of the original 2007).

Ethics. In 1990, the International Epidemiology Association³⁷ concluded that, "It is not feasible to obtain the consent, informed or otherwise, of all individuals whose records have become part of a large database such as a nationwide system of linked records, or the archival records of a general hospital. In these and similar situations, informed consent to use such records for epidemiological study may reasonably be delegated to an ethics review committee."

In accordance with these guidelines, ethical issues of this study's data linkage were approved by the Ethics Review Committee at the University of Toronto. Before analysis and after

verification of matches, patient data were rendered anonymous with the exception of WSIB claim number. Using methods designed to protect the confidentiality of all claimants under study, the clinical data were merged with relevant claim-specific WSIB data under a legal Freedom of Information agreement between the employer of the second, third, and fourth authors and the Ontario WSIB. No patient was contacted.

Imputation. Because it is wasteful of information, deleting those subjects with missing information from the analysis is often inappropriate. Miettinen's⁴⁹ indicator method of imputation was used as a suitable alternative. This modeling approach draws the regression information from those subjects for whom the information is available, while denoting other subjects with dummy variables. The result is a β coefficients adjusted for missing values.

Treatment. Canadian Back Institute clinics provide active physiotherapy, primarily for mechanical spinal pain of musculoskeletal origin. They are secondary-care rehabilitation facilities that focus on pain control in acute, subacute, and chronic ambulatory populations. The rare patients with back pain who have suspected systemic disease and those who have sustained trauma sufficient to produce severe bony injury or major neurologic sequelae are referred elsewhere.

All patients follow a structured protocol of active exercise. The WSIB patients in 1994 were treated daily for 1 to 3 hours for a maximum of 30 days. Treatment progressed through three stages of recovery: pain control, recovery of movement, and physical conditioning. The number of treatment hours per day, the number of days in each stage, and the total treatment time were adapted to the needs of each patient. Both treating staff and patients had the option to conclude the program at any time that return to work or normal activities of daily living became possible.

Statistical Analysis. Outcomes were assessed using survival analysis, calculated by the methods of Cox proportional hazards regression (SAS System for Windows, ver. 6.12; SAS Institute, Cary, NC) to find the best multivariable model(s) predicting outcome. The Cox model uses more information—the survival times—than the logistic model, which considers a binary-type outcome and does not account for time to an event.³⁸

In true studies of survival, in which the outcome is death, failure is a negative experience. In this study, the fewer the cumulative days collecting WSIB benefits, the more positive the outcome in terms of health. Thus, hazard rate ratios (HRR) less than 1 indicate an increased risk of time receiving benefits.

The outcome, time receiving benefits, is a cumulative measure and the concept of an actual endpoint event is ill-defined in this case; however, survival analysis has been used previously for non-time-to-event data. Dudley et al¹⁵ concluded that with Cox regression, it is possible to overcome problems of highly skewed data, arbitrary judgments in dichotomizing the outcome, and assumptions about the underlying distribution of the response variable. Thus, Cox proportional hazards methods were deemed appropriate for this outcome.

A data-splitting technique^{29,30} was used to develop and test the multivariable models. Data-splitting is a method for obtaining a nearly unbiased internal assessment of accuracy. With this technique, a 50% random sample of the full dataset (dataset split in half) was used for model development (BUILD sample) and the entire dataset (TEST sample) for validation.

Table 2. Descriptive Statistics for the Clinical Cluster of Ontario Workers' Safety & Insurance Board Claimants Attending 1 of 20 Physiotherapy Clinics in 1994

Variable	Category	n	%	Duration in Days			LRT <i>P</i> Value
				Median	Mean	SE	
Comorbidity	no	1244	78.9	48	80.02	2.56	0.8038
	any	332	21.1	48	77.11	4.67	
	Total	1576	100.0				
Constancy of pain	constant	745	39.5	58	99.55	3.81	≤0.0001
	intermittent	1139	60.5	43	70.35	2.43	
	Total	1884	100.0				
Diagnosis	Pattern 1	1083	62.9	48	80.90	2.83	≤0.0001
	Pattern 2	345	20.0	43	77.54	4.84	
	Pattern 3	21	1.2	121	165.05	30.46	
	Pattern 4	1	0.1	365	365.00	—	
	Pattern 5	95	5.5	87	112.73	9.82	
	alternative	178	10.3	46.5	69.58	5.74	
L-4	negative	1349	98.0	48	82.27	2.56	0.2098
	positive	27	2.0	82	106.74	17.21	
	Total	1376	100.0				
L-5	negative	1320	97.9	48	80.89	2.54	0.0083
	positive	28	2.1	82	135.07	21.37	
	Total	1348	100.0				
S-1	negative	1341	98.2	48	80.75	2.52	0.0029
	positive	24	1.8	118.5	152.63	21.08	
	Total	1365	100.0				
Saddle sensation	negative	1102	99.7	48	81.86	2.80	0.9754
	positive	3	0.3	54	71.33	23.59	
	Total	1105	100.0				
Straight leg raising	negative	1037	96.9	47	76.51	2.69	0.0016
	positive	33	3.1	90	144.88	20.16	
	Total	1070	100.0				
Femoral nerve stretch	negative	994	98.5	49	82.34	2.96	0.1634
	positive	15	1.5	85	134.73	30.54	
	Total	1009	100.0				
Nonorganic signs	0-2	1404	90.6	47	79.93	2.45	≤0.0001
	3+	146	9.4	73	108.08	7.73	
	Total	1550	100.0				
Pain location	back/butt	1064	61.9	43	70.06	2.50	≤0.0001
	leg	656	38.1	60	101.79	4.11	
	Total	1720	100.0				
Previous episode	no	116	6.1	64	94.48	8.66	0.0445
	yes	1778	93.9	48	81.47	2.19	
	Total	1894	100.0				
Sleep disturbance	no	802	44.4	38.5	64.76	2.88	≤0.0001
	yes	1006	55.6	59	96.55	3.09	
	Total	1808	100.0				
		n		mean		SD	
Visual Analogue Scale-back pain		1158		4.98		2.4	
Visual Analogue Scale-leg pain		617		1.96		2.9	

LRT = log rank test; SE = standard error; SD = standard deviation.

Multivariable modeling and validation consisted of five subanalyses: 1) modeling within each cluster, 2) modeling statistically significant factors from the first analysis, 3) testing the Cox regression proportional hazards assumption, 4) model validation, and 5) assessment of accuracy and predictive value.

Analysis 1. From the BUILD sample, a multivariable model was developed to identify the statistically significant variables from each cluster (clinical and sociodemographic), using a forward stepwise selection procedure with a significance level for entry and exit set at $P = 0.10$. Collett¹¹ suggests avoiding rigid application of a particular significance level with this selection

procedure. To guide decisions on entering and omitting terms, the significance level should not be too small; a 10% level is recommended.¹¹

Analysis 2. All significant variables from Analysis 1 were then entered into a multivariable model with the questionnaire score, to determine the best model to predict outcome, using the same selection procedure and significance levels. This combined analysis approach using multiple clusters and predictors has been previously shown to enhance prediction in studies of persistent pain.^{32,59}

Table 3. Descriptive Statistics (Sociodemographic Cluster): Ontario Workers' Safety & Insurance Board Claimants Attending 1 of 20 Physiotherapy Clinics in 1994

Variable	Category	n	%	Duration in Days			LRT P Value
				50%	Mean	SE	
Gender	female	549	27.7	50	83.72	3.98	0.4356
	male	1435	72.3	48	80.79	2.41	
	Total	1984	100.0				
Industry	primary	13	1	36	80.08	29.79	≤0.0001
	manufacturing	546	42.6	49	79.32	3.84	
	construction	135	10.5	81	130.99	10.27	
	transportation	197	15.4	43	72.64	5.68	
	public	391	30.5	46	76.15	4.56	
	Total	1282	100.0				
Physical demands	sedentary	34	2	46	60.71	12.36	0.0008
	light	110	6.6	40.5	67.75	8.71	
	medium	484	29	44	71.32	3.77	
	heavy	1040	62.4	53	87.71	2.96	
	Total	1668	100.0				
Strength requirements	limited	139	7.4	44	65.27	5.84	0.1055
	light	293	15.6	50	83.91	5.49	
	medium	966	51.6	48	82.16	2.99	
	heavy	475	25.4	51	83.16	4.25	
	Total	1873	100.0				
		n	Mean	SD	Minimum	Maximum	
Age (yr)		1926	37.14	10.1	16	64	
Weekly benefits paid (CDN\$)		1974	420.29	497.7	40	9918.00	
Weekly pre-accident Earnings (CDN\$)		1976	599.22	238.64	40	1615.00	
Lagtime (days)		1984	21.46	19.37	0	90	

LRT = log rank test; SE = standard error; SD = standard deviation.

Analysis 3. A piecewise proportional hazards model was used to test whether each variable satisfied the proportional hazard assumption. When the proportional hazards assumption is violated, the effect of a variable on outcome cannot be summarized by a single HRR, but rather can only be expressed as a function of time.² Based on a hypothetical three-phase prognostic process for low back pain,^{35,57} the piecewise proportional hazards model trichotomized the follow-up time variable into phases: 30 days or less, 31–180 days, and more than 180 days. Product terms were then formed among the three time levels and each variable. The piecewise proportional hazards model was compared with a plain proportional hazards model using likelihood ratio statistics to determine whether there was departure from the proportional hazards assumption. Significant terms were regarded as evidence of nonproportionality and were refitted to account for the time-varying nature of the covariate. The piecewise proportional hazards model assumes that the hazard is constant within a time interval but can change from one interval to the next.⁸

Analysis 4. A concordance (or c) index is a widely applicable measure of predictive discrimination. The c-index was used to validate the predictive accuracy of the model, developed with the BUILD sample, in an independent TEST sample.³¹ An increase in the c-index is expected as long as the progressive addition of factors improves the discrimination of the model. When a variable is added and the c-index plateaus or decreases, that factor is regarded as a noise variable and is excluded to avoid overfitting in the final model.³⁴

Explained variation (R^2) is used to describe the relative importance of prognostic factors in Cox regression models. R^2 -type statistics were calculated with a bootstrap technique using

a SAS macro provided by Schemper⁵⁴ and modified for use in this study.

Analysis 5. Important features of a predictive test (in this study, the final multivariable model) are sensitivity, specificity, and predictive value. Sensitivity is a measure of accuracy for predicting adverse outcomes. In this study, it is the proportion of those with prolonged cumulative time receiving benefits that the model predicts correctly.¹⁶ Specificity is a measure of accuracy for predicting good outcomes (normality). It is the proportion of claimants without prolonged cumulative time receiving benefits that the model predicts correctly.¹⁶

Once the results of a test are available, whether positive or negative, sensitivity and specificity are no longer of primary significance to the clinician. Predictive value provides information about the meaning of a positive or negative test result. Positive predictive value is the probability of prolonged cumulative time receiving benefits, given a positive (high-risk) test result.⁴² Negative predictive value is the probability of no prolonged cumulative time receiving benefits, given a negative (low-risk) test result.⁴²

To conduct this assessment, prolonged time was arbitrarily defined as more than 3 months of cumulative time receiving benefits. A total predictive score ($X\beta$ value) was calculated for each claimant based on the β coefficients and characteristics of the eight factors in the final Cox regression model. To develop 2×2 contingency tables, claimants were categorized as at either high or low risk of chronicity based on the distribution of predictive scores ($X\beta$). To obtain multiple assessments of accuracy, predictive scores were categorized into quantiles (10th, 25th, 50th, 75th, and 90th). Because the lower the score the lower the HRR (*i.e.*, longer time receiving benefits), those at or

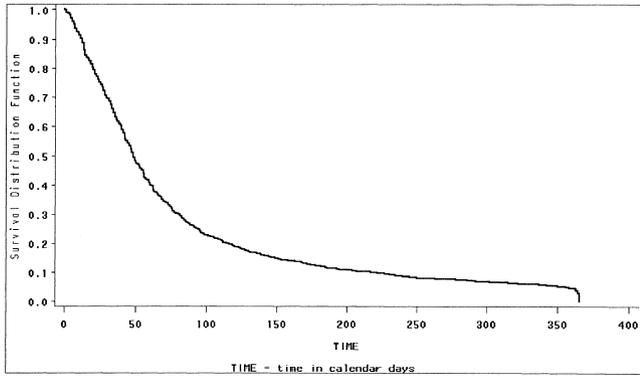


Figure 1. Kaplan–Meier estimate of the cumulative time receiving benefits (survival time distribution) for 1752 Ontario Workers' Safety & Insurance Board claimants attending one of 20 physiotherapy clinics in 1994.

below the quantile were categorized as high risk; those above were low risk. Using five categories of predictive score, sensitivity, specificity, and predictive value were calculated over a range of predictor score cutoff points.

■ Results

Because distribution of survival times tends to be positively skewed, the median is the preferred summary measure.¹¹ For the 1984 claimants with cumulative time receiving benefits information, the median survival time using Kaplan–Meier estimates was 48 days (95% confidence limits, 46–50 days). That is, there was a 50% chance that a claimant would continue to receive benefits (survive) for 48 days or more. The mean (\pm SD) survival time for the entire cohort was 81.65 ± 91.95 days. For those with completed or rescaled questionnaires, the mean time receiving benefits (81.68 ± 91.99 days) was not significantly different than the mean for those missing more than two questionnaire items (81.24 ± 91.89 days; $t = 0.069$; $df = 1982$; $P < 0.945$).

The log rank test was used to test the null hypothesis that the survivor functions across categorical levels of a variable were no different for the clinical cluster (Table 2A) and the sociodemographic cluster (Table 3A).

Only 2.3% of the cohort received benefits for all 365 days; 12.2% accumulated 6 months or more time receiving benefits. Figure 1 displays the Kaplan–Meier estimate of the survival time distribution for this cohort. The steepness of the curve in the first 90 days indicates that symptoms of many claimants with acute low back pain potentially improved promptly, similar to results in other studies.^{34,35,55} There was the usual general flattening of the survival curve from approximately 200 to 365 days indicating the possible onset of chronicity.

Analysis 1

Of those with a documented outcome ($n = 1984$), an approximate 50% random sample ($n = 1000$) was used for multivariable model development (BUILD sample). In the clinical cluster, there were seven significant predictors: pain referred into the leg, three or more positive

nonorganic signs, intermittent (*vs.* constant) pain, a previous episode of low back pain, any comorbidity, positive S1 neurologic signs, and sleep disturbance. In the sociodemographic cluster, there were four significant predictors: working in the construction industry, age, lag time from injury to treatment, and light strength requirements of the job (as determined by patients' perceptions of their job tasks).

Analysis 2

Sleep disturbance from the clinical cluster was not included in this analysis, because of a similar item in the questionnaire. Multivariable Cox proportional hazards regression showed eight significant predictors. Five were associated with longer time receiving benefits compared with their reference groups: 1) working in the construction industry, 2) older age, 3) lag time from the date of injury to the first day of physiotherapy treatment, 4) pain referred into the leg, and 5) three or more positive Waddell⁶¹ nonorganic signs; three predictors were associated with reduced time receiving benefits: 1) higher values of patient questionnaire score, indicating better function, 2) intermittent pain, and 3) a previous episode of low back pain (Table 4).

Analysis 3

On completion of the model selection process, the four factors that showed initial evidence of nonproportionality (lag time, leg pain, three or more positive nonorganic signs, and questionnaire score) were refit to account for violation of the proportional hazards assumption (Table 5). Refitting the model did not change the direction or statistical significance of the HRR for the four time-independent variables. Refitting resulted in some changes in the time-varying covariates. For lag time and questionnaire score, the HRRs had a waning effect with time: The first two time intervals (short and medium) were statistically significant. Thus, these factors showed an association with time receiving benefits in these time periods, but after 6 months after injury, they contributed little to the prediction model. For leg pain, the HRRs had a more rapidly waning effect with time: The association between leg pain and the outcome was strongest in the first interval, 0–30 days, and negligible for the remainder of the follow-up period.

Nonorganic signs maintained the same directionality of its effect but was no longer statistically significant when the time-varying component was included. Because of this absence of statistical significance, Table 5 was refitted to help determine the effect of nonorganic signs on the final model. Likelihood ratio statistics showed that categorizing nonorganic signs as a binary time-independent variable (9838.107–9837.427 with $17 - 15 = 2$ df ; $0.5 < P < 0.75$) and then omitting it entirely (9840.909–9837.427 with $17 - 14 = 3$ df ; $0.25 < P < 0.5$) provided no significantly better fit than the model presented in Table 5. Therefore, nonorganic signs was maintained as a time-varying covariate in the final model.

Table 4. Multivariable Cox Regression Analysis (Forward Stepwise) for Significant Variables From the Two Clusters and Questionnaire Score

	HRR	95% CI	P Value
Predictors associated with increased cumulative time on benefits			
Construction Industry	0.495	(0.377, 0.651)	0.0001
Age	0.990	(0.984, 0.996)	0.0015
Lagtime	0.988	(0.984, 0.991)	0.0001
Leg pain	0.856	(0.741, 0.988)	0.0342
3+ nonorganic signs	0.781	(0.602, 1.012)	0.0615
Predictors associated with reduced cumulative time on benefits			
Questionnaire score	1.029	(1.022, 1.036)	0.0001
Intermittent pain	1.197	(1.042, 1.374)	0.0111
Previous episode	1.595	(1.173, 2.168)	0.0029

CI = confidence interval; Questionnaire = modified version of Low Back Outcome Score; HRR = hazard rate ratio, less than 1 indicated an increased risk of time on benefits, i.e., longer time on benefits.

There was no consistency for any of the time-varying covariates in the third time frame. The directionality of the HRR for all four time-varying covariates was reversed, indicating that after 6 months after injury, the time-varying covariates contributed little to the prediction model. A likelihood ratio statistic showed that Table 5 was a significantly better fit to the data than Table 4 (9867.691–9837.427 with $17 - 9 = 8$ *df*; $p < 0.001$) indicating the need to express four of the eight predictors' HRRs as functions of time.

Analysis 4

In the BUILD sample, the c-index continued to increase with the addition of the first six factors but decreased with the inclusion of leg pain (Table 6). This indicates some overfitting in the BUILD sample. Including leg pain and subsequently nonorganic signs for the TEST sample did not hinder discrimination, because the c-index continually increased with the inclusion of each variable. As a result, the final model was not subject to overfitting, in that none of the eight factors was excluded.

Overall, the final model explained 25.2% of the variance (R^2 range, 17.6–29.5) in the BUILD sample and 24.8% in the TEST sample, using 50 bootstrap samples. Table 6 displays the partial and marginal variance explained (R^2) and shrinkage for each factor in the final model. Shrinkage (difference between R^2 [BUILD] and R^2 [TEST]) values were less than 1.0% for all but one variable (construction industry), indicating a reliable model³⁹ (Table 6).

Analysis 5

To simplify the calculation of predictive score, only the first time period was considered for the four factors that violated the proportional hazards assumption. Table 7 summarizes the measures of accuracy and predictive value by outcome and quantile distribution based on the five contingency tables of risk of chronicity (Appendix B). At the 75th percentile, approximately 95% of those with prolonged time (true positives) were identified correctly, and 30% of those without prolonged time (true negatives) were identified correctly. When dichotomiz-

ing the outcome to categorize patients as at high or low risk of more than 3 months of cumulative days receiving benefits, a sensitivity-favoring predictive score (at the 75th percentile) yielded a positive predictive value of 32.4% and a negative predictive value of 93.8%.

Discussion

Building a predictive model for clinical use should focus on the identification of a few variables that can be easily identified and reliably collected in a clinical setting.¹⁴ Eight predictors of time receiving benefits were identified for this occupationally injured cohort.

Those working in the construction industry were approximately half as likely to stop receiving benefits at any given time compared with those in other industries. Several prognostic studies have identified construction work as a predictor.^{9,35,50} Not all jobs with high physical demands, however, result in high symptom reports.⁶

The older the claimant the longer the cumulative time receiving benefits. This predictive ability of age has been reported in previous low back pain research.^{3,5,9,23,35,36,43,50} It may be biologically more difficult for older workers to recover when they have had an injury, potentially leading to longer time receiving benefits.

The longer the lag time from injury to treatment, the longer the cumulative time receiving benefits. This is similar to other findings stating that the probability of return to work decreases as the length of time away from work increases.^{47,57} A structural correlation between lag time and the outcome is expected because of how the outcome was determined. Because the measurement of outcome

Table 5. Multivariable Cox Regression Analysis for Significant Variables Including Time-Varying Covariates

	HRR	95% CI	P Value
Predictors associated with increased cumulative time on benefits			
Construction industry	0.510	(0.388, 0.670)	0.0001
Age	0.991	(0.985, 0.997)	0.0033
Lagtime			
short	0.977	(0.969, 0.986)	0.0001
medium	0.988	(0.984, 0.992)	0.0001
long	1.010	(1.001, 1.019)	0.0339
Leg pain			
short	0.720	(0.543, 0.955)	0.0225
medium	0.871	(0.723, 1.049)	0.1451
long	1.372	(0.889, 2.117)	0.1531
3+ nonorganic signs			
short	0.741	(0.412, 1.330)	0.3150
medium	0.779	(0.562, 1.081)	0.1353
long	1.323	(0.650, 2.692)	0.4397
Predictors associated with reduced cumulative time on benefits			
Questionnaire score			
short	1.043	(1.031, 1.056)	0.0001
medium	1.023	(1.013, 1.033)	0.0001
long	0.986	(0.960, 1.011)	0.2691
Intermittent pain	1.159	(1.008, 1.333)	0.0388
Previous episode	1.538	(1.130, 2.092)	0.0062

CI = confidence interval; short = 0–30 days; medium = 31–180 days; long = 180–365 days; Questionnaire = modified version of Low Back Outcome Score; HRR = hazard rate ratio, less than 1 indicated an increased risk of time on benefits, i.e., longer time on benefits.

Table 6. Concordance (c) Index, R², and Shrinkage* for the BUILD and TEST Samples

Factor	c Index (%) BUILD sample (n = 872)	c Index (%) TEST sample (n = 1752)	Partial R ² BUILD sample (%)	Partial R ² TEST sample (%)	Shrinkage (%)
Questionnaire score	60.2798	60.945	6.45	6.45	0.00
Lagtime	64.9717	65.9125	6.34	7.27	-0.93
Construction work	65.8942	66.4543	2.57	1.35	1.22
Age	66.208	66.7049	0.77	0.60	0.17
Intermittent pain	66.4037	66.891	0.44	0.52	-0.08
Previous episode	66.8103	67.0817	0.75	0.25	0.50
Point where c index stopped increasing in the BUILD sample					
Leg pain	66.7644	67.1431	1.07	0.85	0.22
Nonorganic signs	66.9396	67.3033	0.56	0.51	0.05

* Shrinkage values for the difference between R² in the BUILD and TEST samples.

and lag time begin at the same time, all or a portion of the lag time is included in the measurement of cumulative time receiving benefits. Nevertheless, lag time was an important variable to assess and control for in the multivariable analysis, in that it predicted the outcome and proxied for differing clinical-predictor assessment times at baseline, which may have altered the predictors' values.

Claimants with leg pain had a higher probability of increased time receiving benefits compared with the reference patients with back pain only. Burton et al.⁷ reported that leg pain was a predictor of poor Roland Morris disability score among acute primary care patients observed for 1 year after injury. This association is clinically intuitive. Referred or radicular pain indicates a more widespread injury with possible neural compromise that may contribute to prolonged symptoms and, subsequently, longer time receiving benefits.

The identification of nonorganic signs as a significant predictor in this study confirms the hypothesis of Gatchel et al.²² that chronic low back pain disability and extended duration of benefits reflect more than just a pure physical disorder or single personality trait. There appears to be a significant psychosocial component contributing to prolonged time receiving benefits.

The higher the questionnaire score (functional status), the shorter the time receiving benefits. The results of the multivariable analysis confirm that this instrument can

discriminate prognosis between groups of patients who differ in disability levels when seen early in their course.

The probability of increased time receiving benefits was lower for those with intermittent pain at assessment compared with the reference, constant pain. No reports of pain constancy as a predictor were found in the back pain literature, although this association is clinically intuitive. Intermittent pain reflects symptoms of a mechanical nature, in which resolution is expected more quickly than in the chronic state,⁴⁸ in which nonmechanical factors, both psychological and physiologic,²¹ may contribute to prolonged symptoms and, subsequently, longer time receiving benefits.

Claimants with a previous episode had a lower probability of increased time receiving benefits than the reference subjects with no previous episodes. This contradicts results in several studies in the back pain literature^{6,12,58}. Burton and Erg⁶ state that a previous history of back pain is the most consistent predictor of future trouble. Troup et al.⁵⁸ observed 2891 workers during 1 year in Britain and concluded that a history of previous back problems was the strongest risk factor of future low back pain recurrence (not duration, as in this study) among an industrial cohort. Coste et al.¹² discovered that previous episodes of low back pain was predictive of lower probabilities of both return to work and recovery.

The counter-intuitive finding in this cohort may indicate a learning effect among physiotherapy attendees, whereby those who have encountered back pain in the past may have better pain-coping skills during future episodes. They may have more future trouble⁶ but in shorter episodes. Hazard et al.³³ suggested that those who have survived previous episodes of pain with relatively little trouble are at reduced risk of future disability than those with first-time occupational injuries and those with more severe prior episodes.

In a clinical setting of secondary care, the difficulty in obtaining an inception cohort is complicated by the existence of three possible "zero-times": claim inception, reported pain inception and start of treatment, and clinical data collection. In a prognosis study of claims data,

Table 7. Sensitivity, Specificity, and Predictive Value by Predictive Score (Xbeta) Distribution for Outcome Defined as >3 Months of Cumulative Time on Workplace Safety & Insurance Board Benefits (Chronicity >3 Months)

Percentile	Sensitivity	Specificity	PPV	NPV
10th	26.1	95.5	66.7	78.7
25th	50.1	83.7	51.7	82.8
50th	75.3	58.8	38.9	87.2
75th	94.0	31.6	32.4	93.8
90th	98.2	12.8	28.2	95.4

PPV = positive predictive value; NPV = negative predictive value.

new claimants must be sought by ensuring that study participation occurs on the first disability day or uses consistently short lag times. An inception cohort design was used in which the inception point was the accident date according to WSIB records, which usually equates to the date of first lost time from work in the current episode. There is no waiting period for benefits in Ontario. All clinical and questionnaire data were captured on the first day of clinic attendance. All claimants had a lag time of less than 91 days. The mean lag time was 3 weeks, and the median was 2 weeks; 90% of the sample had lag times of less than 8 weeks; thus, claimants were at similar acute stages of recovery, helping to reduce any assembly bias.

The search to reduce costs of occupational injuries has led to the use of return to work as a readily available measure of medical care effectiveness.³ The quality of many epidemiologic studies relies heavily on the accurate measurement of the dependent variable, but this information is not always readily available. Because employers and/or patients have to be contacted frequently for work-verification status, actual return to work is a costly and time-consuming outcome to determine. To overcome these problems, the present outcome measure (cumulative time receiving benefits) was abstracted from the WSIB administrative database, as in other low back pain prognosis studies.^{25,34,35} Although it is an indirect measure of return to work, cumulative time receiving benefits is routinely and accurately collected throughout the first year of follow-up after claim inception in what appears to be an unbiased way for all lost-time claimants. Return to work often assumes complete recovery from injury, yet as many as 60% of workers are unable to remain at work after their initial return.³ Important prognostic information may be lost in studies that rely on only one return to work assessment after injury without further follow-up for the reinitiation of lost time,^{3,13} using this more complex outcome variable helped capture the episodic and recurrent nature of back pain.

In this study setting, there was little variation in actual treatment, thereby reducing the possibility of confounding by treatment regimen, because of the extensive steps taken by CBI clinics to ensure a standardized protocol for all patients.²⁶⁻²⁸ A limitation of many database-type studies is the investigators' inability to control the quality of data collected and treatment provided. Using clinics, as in this study, that are fully integrated, with the same centrally coordinated data collection tools and philosophy of treatment, reduces the potential for poor data quality of this sort.

Approximately 2.5% of the working population lose time from work annually because of low back pain.^{56,60} Frank et al.²¹ state that a major limitation of etiologic or prognostic studies of occupational low back pain is that they are restricted to reported and WSIB-accepted workplace claims. This is also a limitation of this study. Some workers may have chosen to work while in pain rather

than take time off or may have taken time off and received compensation by other disability insurance plans.

Selection bias due to referral, for example, mostly tends to result in narrowed ranges for predictor variables (increased subject homogeneity) and bias the results toward the null hypothesis.⁵³ Because the clinical database is dependent on physician referral, there may be centripetal bias. Physicians do not refer all their patients to a single clinic or clinic system in Ontario; thus, only certain patients with back pain may gravitate toward this type of treatment. The more severe or mildly injured may not seek treatment in an active rehabilitation program, causing a referral filter or spectrum (severity) bias. Recent evidence from an Institute for Work and Health pilot project of rehabilitation providers,⁵¹ however, showed that the CBI clinics used in this study have patients with pain severity and functional status measures similar to those in six other independent physiotherapy clinics in Ontario.

Overall, this model explains 25.2% of the outcome's variance. When explained variation was calculated for the test sample, R^2 values were generally slightly reduced but similar to those of the BUILD sample. Higher R^2 values have been reported in other prognostic studies.³⁴ Hogg-Johnson and Cole³⁴ studied a variety of soft tissue injuries and used a combination of two questionnaires, administered at baseline and at 4 weeks lost time, in their final model, with a resultant $R^2 = 39\%$. In the current study, adopting a more narrow definition of soft tissue injury (low back pain), determined at only one baseline interview and examination and focusing on multivariable Cox regression to determine significant predictors may have reduced the amount of explained variation in the outcome.²¹ Because time receiving benefits is affected by factors beyond the scope of any health-care intervention,¹⁹ the outcome studied here may have been influenced by factors other than physical recovery. Subtle psychological factors may codetermine and/or confound the results.^{7,14,40} Motivation, emotional reaction, cultural milieu, local-sectoral unemployment rate, claim adjudication, and job satisfaction may override improved physical function in a patient's decision to continue receiving benefits.⁴⁴⁻⁴⁶ Other factors such as physician attitudes and treatment styles may influence outcome.⁴¹ Therefore, rehabilitation is only one of several influences on a worker's postinjury chances of returning to employment.

A highly sensitive predictive test identifies all the claimants with prolonged lost time but may result in mistakenly labeling some of those with shorter time (prognostic false positives) as prolonged. Thus, a highly sensitive test should be chosen only when there is an important consequence in missing a future chronic case. Low specificity leading to a low positive predictive value has potentially both negative ethical and economic implications. In the context of this study, false-positive cases, labeled as chronic, may receive more intensive treatment than necessary. Ethically, some intensive reha-

bilitation programs risk reinforcing sick role behavior.¹⁸ Forecasting a strong chance of a poor outcome correctly or incorrectly may have a negative impact *per se*.¹⁰ Economically, these risks are not balanced by any benefits for the false-positive subjects mislabeled as “destined for chronicity” by a nonspecific prognostic test. In fact, these patients pay more for unnecessary treatment.

Overly optimistic predictions of outcome risk can create disappointment, anxiety, and anger when the patient's recovery does not proceed as planned. False-negative subjects, in whom the identification of a high risk of chronicity is missed, may be denied necessary rehabilitation because they were deemed at low risk, thereby prolonging their recovery. This also has both negative economic and ethical implications. Economically, an opportunity to reduce wage replacement and further rehabilitation costs may have been missed. Ethically, the chance to benefit from an appropriate course of treatment may have been lost because of an erroneous prognostic test result.¹⁸

Because a missed opportunity to benefit from intensive treatment was determined by the authors to be of greater consequence than being mislabeled as “likely to become chronic,” sensitivity was viewed as slightly more important than specificity. However, if the marginal benefit of more intensive treatment for “screen positives” is regarded as unproven, which is arguable here, then it may be preferable to accept more false negatives to reduce any labeling effects arising from low specificity. These decisions depend on the precise purpose of screening and the treatments available in a given setting.

Finally, the predictive value of a prognostic test is not a property of the test alone. It is determined by sensitivity and specificity of the test and the incidence of the disorder. For a diagnostic test, the left-hand column total in a 2 × 2 contingency table represents disease prevalence. For a prognostic test, however, this total represents the incidence of future complication at a defined follow-up time.¹⁸ The incidence of chronicity (at 3 months) in this study was 26%. Given that the higher the incidence the greater the positive predictive value and the lower the negative predictive value, it is not surprising to find a low positive predictive value with this low incidence. The high negative predictive value (94%) showed that for those judged as being at low risk of chronicity, the chance of remaining on benefits for more than 3 months was only 6%.

■ Conclusion

No one predictor variable cluster dominated the final predictive model. The presence of questionnaire score, four clinical cluster factors, and three sociodemographic cluster variables in that model indicate the importance of obtaining comprehensive patient information from at least three domains (clinical, sociodemographic, and patients' self-reports) when developing a prognostic model for low back pain.

Clinicians should be aware of what factors differentiate claimants who become chronically disabled from those who do not. This multivariable model indicates robust and reasonably accurate clinical predictive capacity. Although the inherent uncertainty of prognostication can never be eliminated, because the progress of low back pain is highly variable, this does not negate the importance of pursuing accurate models for predicting outcomes. This research identified eight factors for time receiving workers' compensation benefits among claimants with low back pain. This model discriminates between high- and low-risk claimants using the eight prognostic factors. Few low-risk claimants continue to receive benefits for more than 3 months. This prognostic value can be used for more appropriate randomization in future clinical trials by focusing treatment interventions on patients at high risk of chronicity.

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■ Appendix A

Patient Questionnaire

Note that question 1 is not included in the calculation of questionnaire score. The result is an 18-item survey.

INFORMATION ON YOUR INJURY									
<i>THE FOLLOWING INFORMATION IS NECESSARY TO PROVIDE THE THERAPIST WITH A BETTER UNDERSTANDING OF YOUR INJURY.</i>									
1. AREA(S) AFFECTED	<input type="checkbox"/> NECK	<input type="checkbox"/> ARM	<input type="checkbox"/> BACK	<input type="checkbox"/> LEG	<input type="checkbox"/> OTHER				
2. CURRENT EPISODE CAUSED BY	<input type="checkbox"/> WORK ACCIDENT		<input type="checkbox"/> MOTOR VEHICLE ACCIDENT						
	<input type="checkbox"/> UNKNOWN		<input type="checkbox"/> OTHER						
3. ONSET OF PAIN	<input type="checkbox"/> SUDDEN		<input type="checkbox"/> GRADUAL						
4. LENGTH OF TIME IN PAIN	<input type="checkbox"/> 2 WEEKS OR LESS		<input type="checkbox"/> 3-10 WEEKS	<input type="checkbox"/> 11 WKS - 6 MO	<input type="checkbox"/> + 6 MONTHS				
5. ABILITY TO DO DOMESTIC CHORES	<input type="checkbox"/> NORMAL		<input type="checkbox"/> MOST BUT SLOWER	<input type="checkbox"/> FEW	<input type="checkbox"/> NONE				
6. SPORTS AND ACTIVITIES	<input type="checkbox"/> NORMAL		<input type="checkbox"/> LESS	<input type="checkbox"/> NONE					
7. IS A LAWYER INVOLVED WITH YOUR INJURY?	<input type="checkbox"/> NO		<input type="checkbox"/> YES						
8. SMOKER	<input type="checkbox"/> NO		<input type="checkbox"/> YES						
9. NEED FOR REST DURING THE DAY	<input type="checkbox"/> UNCHANGED		<input type="checkbox"/> REST LESS THAN 1/2 DAY	<input type="checkbox"/> REST MORE THAN 1/2 DAY					
10. I VISIT MY DOCTOR	<input type="checkbox"/> NEVER		<input type="checkbox"/> RARELY	<input type="checkbox"/> ONCE A MONTH	<input type="checkbox"/> MORE THAN ONCE A MONTH				
11. NEED FOR PAIN MEDICATION	<input type="checkbox"/> NEVER		<input type="checkbox"/> OCCASIONALLY	<input type="checkbox"/> ONCE A DAY	<input type="checkbox"/> SEVERAL TIMES / DAY				
PLEASE INDICATE HOW YOUR PAIN HAS AFFECTED THE FOLLOWING ACTIVITIES :									
	12. WALK	13. SIT	14. STAND	15. LIFT	16. DRESS	17. WORK	18. TRAVEL	19. SLEEP	
NO EFFECT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
MILD	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
DIFFICULT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
IMPOSSIBLE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

■ Appendix B

Frequencies for Calculating Sensitivity, Specificity, and Predictive Value

Table a. Frequencies of risk of chronicity for the 10th percentile (Xbeta = -0.133) of predictive score: >3 months of cumulative time on Workplace Safety & Insurance Board (WSIB) benefits?

		Yes	No	Total
Predictive	High risk	118	59	177
Test	Low risk	335	1240	1575
	Total	453	1299	1752

Table b. 25th percentile (Xbeta = 0.600) of predictive score: >3 months of cumulative time on WSIB benefits?

		Yes	No	Total
Predictive	High risk	227	212	439
Test	Low risk	226	1087	1313
	Total	453	1299	1752

Table c. 50th percentile (Xbeta = 1.207) of predictive score: >3 months of cumulative time on WSIB benefits?

		Yes	No	Total
Predictive	High risk	341	535	876
Test	Low risk	112	764	876
	Total	453	1299	1752

Table d. 75th percentile (Xbeta = 1.693) of predictive score: >3 months of cumulative time on WSIB benefits?

		Yes	No	Total
Predictive	High risk	426	888	1314
Test	Low risk	27	411	438
	Total	453	1299	1752

Table e. 90th Percentile (Xbeta = 2.139) of predictive score: >3 months of cumulative time on WSIB benefits?

		Yes	No	Total
Predictive	High risk	445	1132	1577
Test	Low risk	8	167	175
	Total	453	1299	1752