

# Prognostic factors associated with low back pain outcomes

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## ABSTRACT

**INTRODUCTION:** An improved understanding of prognostic factors associated with low back pain (LBP) outcomes will refine expectations for patients, clinicians and funders alike and improve allocation of health resources to treat the condition.

**AIM:** To establish the link between a range of clinical and sociodemographic prognostic variables for LBP against three separate, clinically relevant outcome measures.

**METHODS:** This was a retrospective, non-experimental study of 1076 consecutive LBP cases treated during a three-year period. Multivariate logistic regression analysis was used to determine the association between potential prognostic variables and outcome measures: clinically relevant reduction in pain, improvement in perceived function, and successful return to work six months after rehabilitation.

**RESULTS:** Patients with clinically relevant improvements in LBP were more likely to have a shorter duration of pain (odds ratio [OR] 1.89), lower baseline pain (OR 1.19), a directional preference for extension activities (OR 1.45) and a history of spine surgery (OR 1.38). Clinically relevant gains in perceived function were observed in patients who were younger (OR 0.98) or those with shorter symptom duration (OR 1.74). Prognostic variables associated with a successful return to work included being female (OR 1.79), having a job available (OR 2.36), intermittent pain (OR 1.48) or a directional preference for extension activities (OR 1.78).

**DISCUSSION:** This study demonstrated that there are a variety of prognostic variables to consider when determining outcome for an individual with LBP. The relative importance of each variable may differ depending on the outcome measured.

**KEYWORDS:** Low back pain; patient outcome assessments; prognosis

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## Introduction

In a recent health survey of the New Zealand population, 16.9% of participants reported that chronic pain affected their lives and 47.5% of those with chronic pain nominated the back or neck as a site of pain symptoms.<sup>1</sup> The recently released Australian National Pain Strategy highlighted the heavy burden of chronic low back pain (CLBP) on the community, economy and health care services and called for improvements in the assessment and management of the condition.<sup>2</sup>

There is an increasing awareness of the need to better determine prognostic factors associated

with low back pain (LBP). An improved understanding of the bio-psychosocial factors that may influence the evolution of back pain symptoms, the prognosis of the condition and the success of treatment are key areas in spine pain research. Most patients with LBP want to know what to expect in their future, and many clinicians want to be able to predict their patients' future course once an LBP attack has begun.<sup>3</sup>

There are many reported potential barriers to recovery from both acute LBP (LBP of less than three months' duration) and CLBP. Prognostic studies of acute LBP groups have identified an association between the rate of recovery from an

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acute episode of back pain and previous back pain episodes, distress and job satisfaction.<sup>4,5</sup> A recent review of prognostic factors associated with the development of CLBP (LBP of greater than three months' duration), identified functional impairment, non-organic signs, maladaptive pain-coping behaviours, general health status and the presence of psychiatric comorbidities, as having a significant association with back pain chronicity.<sup>6</sup>

Back pain is a costly and difficult diagnostic and therapeutic dilemma. Cats-Baril and Frymoyer<sup>4</sup> suggest that identifying a patient destined for CLBP early in the course of the illness is a worthwhile goal. Recent research has therefore focused on the development of predictive models to iden-

tify susceptible patients, streamline treatment, modify patient and funder expectations, and improve the efficiency of health care planning.<sup>7-10</sup>

Several LBP prognostic screening tools have been developed to help determine the likely benefit of treatments, such as spinal manipulation<sup>11</sup> and exercise,<sup>12</sup> or to identify patients at increased risk of not returning to work or of developing long-term dependency.<sup>3,13</sup> Hill et al.<sup>14</sup> developed the Keele STartT Back Screening Tool as a simple risk screening tool designed for the primary care practice environment. This questionnaire measures potential risk, based on nine symptomatic and psychosocial features that were shown to be associated with poorer disability outcomes.

Greater understanding of the impact of individual prognostic features, across a variety of LBP outcome measures, will assist in the future development of reliable and validated prognostic models for LBP. The aim of this study was to identify prognostic variables associated with three distinct, clinically relevant outcomes—pain reduction, functional improvement, and return to work—in a cohort of LBP patients treated within a multidisciplinary rehabilitation programme.

## Methods

This was a retrospective, non-experimental study of consecutive LBP patients (n=1076) commencing treatment at eight spine care rehabilitation clinics in New Zealand between March 2007 and March 2010. Clinical data pertaining to potential prognostic variables obtained at the initial patient assessment were used to record baseline information relating to patient demographics, symptoms, injury and employment history, psychosocial and neurological status. Standardised outcome measures relating to pain level, perceived function and vocational status were recorded from a series of standardised outcome measure questionnaires that were completed at initial assessment, discharge and at six-month follow-up.

## Treatment

Each of the eight spine care centres involved in the study used a standardised methodology for the assessment and treatment of back pain.<sup>15,16</sup>

Table 1. Descriptive data for prognostic variables in sample group of referred patients with low back pain (N = 1076)

Continuous variables	Mean	SD
Age (years)	40.6	11.2
Symptom duration (days)	323	343
Initial pain score (NPR)	4.9	2.2
Initial functional score (m-LBOS)	38.9	9.5
Categorical variables	Category	%
Job availability	Available	56.5
	Not available*	24.3
	Unknown	19.2
Previous spinal surgery	Yes	37.5
	No*	62.5
Directional preference	Extension	28.5
	Flexion	2.7
	No preference*	68.8
Constant or intermittent pain	Constant*	49.2
	Intermittent	50.8
Sleep disturbance	Yes*	65.3
	No	34.7
Dominant pain location	Back	89.2
	Leg*	10.8
Gender	Male*	62.5
	Female	37.5
Work status	Working	42.6
	Not working*	57.4

NPR Numeric Pain Rating scale score

m-LBOS Low Back Outcome Score functional questionnaire (modified version) score

\* Reference categories for multivariate logistic regression analysis

The approach classifies mechanical LBP into four clinically relevant subgroups (patterns), based on the location of the dominant pain site (back pain or leg pain of spinal origin), and symptom response to spinal loads (directional preference for extension or flexion postures and activities). A fifth independent subgroup identifies patients with coexisting heightened pain behaviours. Once categorised, patients are treated with education, a pattern-specific exercise programme, Cognitive Behavioural Therapy (CBT), progressive functional reactivation, and work simulation.

### Prognostic variables

Potential prognostic variables were selected from a range of symptomatic and demographic values that have previously been suggested to have an association with LBP outcomes.<sup>11-14</sup> From the data recorded at the initial patient assessment, 12 prognostic variables were chosen and recorded for each patient, including patient age, gender, symptom duration, initial pain score, initial functional score, job availability, previous spine surgery, directional preference, pain consistency, sleep disturbance, work status and dominant pain site (Table 1).

### Outcome measures

Three separate and clinically relevant outcome measures were used to determine the success of the rehabilitation programme. Perceived pain level was recorded using the Numeric Pain Rating scale (NPR).<sup>17</sup> A 20% change in the NPR has been suggested to represent a clinically significant improvement in symptoms<sup>18</sup> and, therefore, a 1.9 point improvement in the 11-point NPR scale was set as the categorical cut-off point for a successful pain outcome for the study.

Perceived functional capacity was recorded utilising a modified version of the Low Back Outcome Score functional questionnaire (m-LBOS) that was modified and validated for use in these clinical settings.<sup>7,8</sup> Lauridsen et al. suggested that a 30% change in perceived functional level is clinically meaningful; accordingly, the criterion for a successful functional outcome in this study was set at a 30% improvement on the 70-point m-LBOS score.<sup>19</sup>

## WHAT GAP THIS FILLS

**What we already know:** Back pain is a complex health issue with a variable and uncertain outcome. Previous research has shown that a wide range of factors may influence the course and prognosis for patients with low back pain.

**What this study adds:** This study has identified a number of specific, clinically relevant prognostic variables associated with a successful, clinically relevant symptomatic, functional and vocational outcome for patients with back pain. The findings of this study will assist in further development of prognostic models to identify patients at a higher risk of developing long-term chronicity following an episode of back pain.

Vocational status is an important determinant of success when recovering from LBP.<sup>15</sup> In this study, work status was categorised at the initial assessment and the six-month follow-up check-point as either 'not working' (not working at pre-injury hours or duties) or 'working' (working at full pre-injury hours or duties).

### Ethics approval

The New Zealand Central Regional Health and Disability Ethics committee advised that this study did not require ethics approval because this research falls under exemption 11.9 of the Ethical Guidelines for Observational Studies: Observational Research Audits and Related Activities.

### Statistical analysis

The data available for the prognostic variables were either categorical or continuous variables (Table 1). Using a forward stepwise selection procedure, multivariate logistic regression was used to model the relationship between all of the prognostic variables and the three independent, binary outcomes:

1. clinically relevant change in pain level;
2. clinically relevant change in perceived function; and
3. work status at six-month follow-up.

If the same dataset used to fit a model is used to test the predictive accuracy of the model, it is likely to be positively biased.<sup>20</sup> The assessment of accuracy on a separate sample provides a

Table 2. Multivariate logistic regression (forward stepwise) analysis for predictors of clinically relevant reduction in pain (n=899)

Variable	Odds Ratio	95% CI	p-value
Shorter pain duration	1.89	1.15–2.78	0.01
Lower baseline pain rating	1.19	1.1–1.29	0.001
Directional preference–extension	1.45	0.94–2.25	0.09
Previous spine surgery	1.38	0.07–1.97	0.08

bias-corrected estimate of accuracy on a training sample and data-splitting is the preferred method to obtain a nearly unbiased internal assessment of accuracy.<sup>21</sup> This technique was therefore used to develop and test the multivariate models, whereby a 67% random sample of the full dataset was used for model development (Build sample), and the entire dataset was used for validation (Test sample). This model validation strategy is based on well-accepted modelling methodologies.<sup>20–22</sup>

Using the Build sample, forward stepwise selection procedures were utilised, with a significance level for entry and exit set at  $p=0.10$ . Collett<sup>23</sup> 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 and a 10% level is recommended.<sup>23</sup> The Receiver Operating Characteristic (ROC) curve is a graphic depiction of the predictive accuracy of a logistic model over a range of cut-off points. The area under the curve is not an extremely sensitive measure when comparing models, but is ideally suited for independent data that were not used to fit a model.<sup>24</sup> ROC curves were computed for validation on all three Test samples.

## Results

There were 1076 patients with LBP referred to the clinics over a three-year period. Table 1 summarises descriptive data for the prognostic variables in this sample group. The mean age of the group was 40.6 years (standard deviation [SD] 11.2; range, 18–76); 62.5% of the group were male and the mean duration of symptoms was 322 days (SD 343 days; median 208 days). The majority (815/1076) of the group had LBP symptoms of 90 days or more duration. Of the 1076 patients in

the initial sample, 899 (83.6%) completed the programme and the relevant outcome questionnaires, 87 (8.1%) withdrew early from the programme, and 90 (8.3%) completed the programme but did not complete the relevant outcome measures. Of the 1076 patients that entered the study, 800 (74.3%) were contacted via telephone and completed the follow-up.

### Prognostic analysis 1—pain reduction

The sample group for the pain reduction prognostic analysis consisted of the 899 patients who completed their rehabilitation and relevant discharge documentation. Multivariate logistic regression (forward stepwise) analysis revealed four key factors related to a clinically relevant (20%) reduction in pain: shorter pain duration, lower baseline pain rating, a directional preference for extension activities to relieve pain, and a history of spine surgery (Table 2). A separate regression analysis on the test sample confirmed the same four factors.

Figure 1 displays the ROC curve (irregular line) for the predictive variables associated with pain reduction in the Test sample. Under the null hypothesis (straight diagonal line), the area under the curve is 0.5; the four predictors improved the area under the curve to 0.62 (95% confidence interval 0.58–0.66). This increase indicates that the model provides better predictive accuracy than can be obtained by chance ( $p<0.001$ ). The model developed using the Build sample had high predictive accuracy for the Test sample.

### Prognostic analysis 2—functional improvement

The sample group for the prognostic analysis for functional improvement consisted of the 899

Figure 1. Reduction in pain: ROC curve of predictive variables for the Test sample

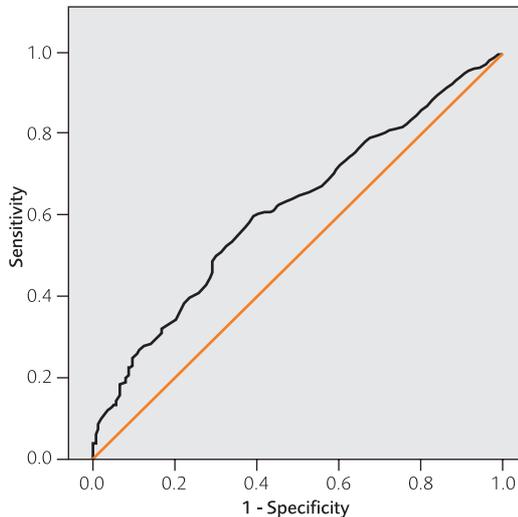


Figure 2. Functional improvement: ROC curve of predictive variables for the Test sample

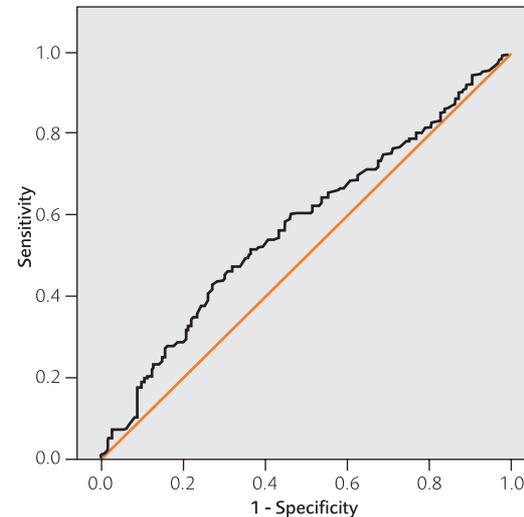
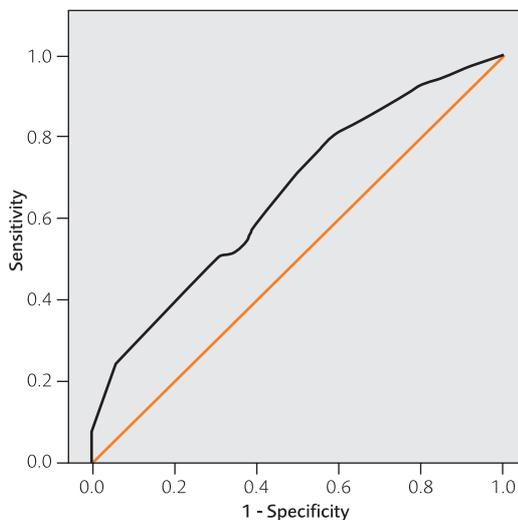


Figure 3. Return to work: ROC curve of predictive variables for the Test sample



The area under the black irregular line in Figures 1–3 represents the combined value of the prognostic variables to predict the eventual outcome. The area under the straight line represents the value if the outcome was predicted by chance. Diagonal segments are produced by ties.

patients who completed their rehabilitation and relevant discharge documentation. Multivariate logistic regression (forward stepwise) analysis revealed two key factors related to a clinically meaningful improvement in function: younger age and shorter pain duration (Table 3). Although

not significant, ‘baseline function’ was retained in the ROC model because this predictor improved the goodness of fit and provided reduction of error (added explanatory power) to the model, even though baseline function was not itself significant when adjusted for the other factors.

Figure 2 displays the ROC curve (irregular line) of predictive variables associated with perceived functional improvement for the Test sample. The three predictive variables improved the area under the curve to 0.57 (95% CI 0.53–0.62).

### Prognostic analysis 3—return to work

The sample group for the prognostic analysis for return to work rates consisted of the 815 patients who completed their rehabilitation and subsequent six-month follow-up questionnaire. Multivariate logistic regression (forward stepwise) analysis revealed four key factors related to successful return to work: female gender, intermittent pain, job availability, and a directional preference for extension activities to relieve pain (Table 4).

Figure 3 displays the ROC curve (irregular line) of predictive variables associated with a successful return to work for the Test sample. The three predictive variables improved the area under the curve to 0.66 (95% CI 0.61–0.71).

Table 3. Multivariate logistic regression (forward stepwise) analysis for predictors of a clinically relevant improvement in function (n=899)

Variable	Odds Ratio	95% CI	p-value
Younger age	0.98	0.96–0.99	0.001
Shorter pain duration	1.74	1.13–2.68	0.012

Table 4. Multivariate logistic regression (forward stepwise) analysis for predictors of successful return to work (n=815)

Variable	Odds Ratio	95% CI	p-value
Female gender	1.79	1.12–2.85	0.014
Intermittent pain status	1.48	0.97–2.26	0.07
Job available	2.36	1.55–3.59	<0.001
Directional preference–extension	1.78	1.03–3.08	0.04

## Discussion

Building a clinical predictive model should focus on the identification of a few variables that can be easily identified and reliably collected in a clinical setting.<sup>21,25</sup> The current study on a large cohort of patients with LBP shows that a number of different clinical factors may contribute to the prognosis for recovery, and that their impact varies depending on the clinical outcome measured.

The odds ratio (1.89) for symptom duration recorded in our study indicates that individuals who achieve a significant improvement in back pain and/or an improvement in perceived function are almost twice as likely to have a relatively shorter duration of LBP symptoms. This association between pain duration and outcomes was expected. A recent meta-analysis of prognosis for acute and persistent LBP by Costa and colleagues identified 33 cohort studies and over 70 different prognostic variables that related to a range of health outcome measures.<sup>26</sup> They concluded that the typical course of acute LBP is initially favourable, and that a shorter period of symptom duration was consistently associated with a positive prognosis.<sup>26</sup> Jette and colleagues studied 2328 patients with LBP and reported that increased time from the onset of symptoms was associated with 40% longer and 17% costlier courses of care.<sup>27</sup> The association between pain duration and outcome in the current study supports the conclusions of

Costa et al.<sup>26</sup> that identifying symptom duration is essential in the prognostic modelling of LBP.

Subjects reporting an improvement in pain levels and a successful return to work were more likely to have had a directional preference for postures or activities that place the spine in an extended position. Alterations in back pain in response to specific mechanical movements and loads on the spine is a well-recognised phenomenon,<sup>28-30</sup> and previous studies have demonstrated a more favourable outcome for LBP patients who demonstrate a directional preference for extension postures and activities.<sup>29</sup> Directional preference for extension is an important consideration with respect to pain reduction and return to work outcome.

The chance of a successful return to work was higher for those presenting with intermittent pain. There does not appear to be any previous reports of pain constancy as a predictor of return to work in the back pain literature. Intermittent pain reflects symptoms of a predominantly mechanical nature; resolution can usually be expected more quickly than with the case of constant pain,<sup>29</sup> where non-mechanical factors, both physiological and psychological,<sup>30</sup> may contribute to prolonged symptoms and delayed recovery.

There is strong evidence to support the value of job availability in achieving a successful voca-

tional outcome.<sup>31-33</sup> Workers are more likely to successfully return to work if they have maintained links with their employer and are provided with a well-constructed, graduated plan for the resumption of their previous tasks.<sup>34</sup> The current study provides further evidence supporting the value of job availability. Patients were more than twice as likely to achieve durable employment if they had a job awaiting them at the conclusion of rehabilitation.

A limitation of many prognostic studies is the investigators' lack of control over the consistency of the treatment and the validity of the collected data. Using fully integrated clinics that employ the same centrally coordinated data collection tools and management philosophy reduced the potential for contamination by poor data quality. Although all the participating clinics use an approach that is based on well-accepted cognitive behavioural therapy (CBT) and functional reactivation principles, the associations observed between prognostic variables and outcomes in this study cannot necessarily be generalised to other groups of patients with LBP receiving other types of care, or no treatment at all.

The statistically significant prognostic variables ( $p < 0.1$ ) identified in this study and listed in Tables 2-4, demonstrated accuracy levels ranging between 0.57 and 0.66 across the three outcomes measured. Fear of activity, anxiety and catastrophising behaviour have all been shown to have strong associations with the development of CLBP.<sup>35,36</sup> Although the clinicians in this study collected data related to potential psychosocial risk factors (i.e. sleep disturbance), validated psychosocial status questionnaires were not routinely used and the prognostic model may be enhanced by the addition of these measures. This deficiency will be addressed in a planned follow-up study that will include a range of validated psychosocial measurements.

A further limitation of the study is that no methods of imputation or substitution were used to address missing data. Those with missing data at baseline were omitted from the study analysis (list-wise); those who had baseline data but were not available for follow-up (dropouts) were included in all aspects of the results except for

the follow-up analysis (pair-wise). The multi-variable models for each outcome were generated on only those who participated in the follow-up, to minimise the effect of dropouts.

The development of a reliable and validated screening tool to accurately predict the prognosis for patients with LBP has been described as the 'holy grail' in spine research.<sup>37</sup> The ability to identify a risk profile is an important step in correctly setting expectations, justifying stratified health resources and developing long-term initiatives to improve the management of spine pain in the community.<sup>38,39</sup> The current study shows the importance of developing prognostic models that take into account the relationship between particular prognostic variables and specific, clinically relevant outcomes. If the desired outcome from rehabilitation is a reduction in pain, the findings of our study suggest that rehabilitation for patients with longstanding symptoms is less likely to be cost-effective. If the goal of rehabilitation is a return to work, symptom duration alone has less influence on outcome and treatment should not be denied on the basis of a prolonged period of LBP.

## Workers are more likely to successfully return to work if they have maintained links with their employer and are provided with a well-constructed, graduated plan for the resumption of their previous tasks

Prognostic models for LBP are an important and evolving area of research. This study has demonstrated that there are a variety of prognostic variables to consider when determining outcomes, and that the relative importance of each variable may differ depending on the outcome measured. While there was some overlap, each outcome placed a different value on the clinical findings. The variability of LBP creates inherent prognostic uncertainty but this does not negate the importance of pursuing accurate predictive models to help manage the condition.

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## COMPETING INTERESTS

Mr Chris Hoffman is a Director and shareholder of The Back Institute. Mr Chris Gregg and Mr Hamilton Hall are shareholders of The Back Institute.