Comparison of Spinal Health Indicators in Predicting Spinal Status in a 1-Year Longitudinal Study

M. Rossignol, MD, MSc, M. Lortie, IngPhD, and E. Ledoux, MSc

A 1-year longitudinal study was performed to assess and compare the predictive qualities of spinal health indicators (excluding the cervical spine) among aircraft assembly workers having at least 1 year seniority in a large assembly plant. Ten health indicators were compared to determine their sensitivity and predictive power with regard to back compensation and absenteeism in 12 months follow-up, and the presence of any limitation at work due to the back, or symptoms to the back at the end of the interval. The initial response to a self-administered questionnaire was obtained from 269 male workers, of whom 205 (76.2%) completed the follow-up questionnaire. Initial prevalence of symptoms to the back was 42.3%, limitation in performing at work was 28.1%, consultation of a health professional was 7.3%, and a history of compensation for the back (ever) was reported by 30.4%. During the year of follow-up, 1616% of the 269 workers initially enrolled were granted 17 compensated episodes. Of the 205 workers who responded to the follow-up, 33 (16.1%) have been absent from work (with or without compensation) because of their back. The presence, at the beginning of the study, of a limitation in performing at work or in activities of daily living and a history of compensation (ever) were the three indicators independently associated with the occurrence of compensation or absenteeism (total work disability) related to a back problem during the following year. The three indicators combined (either one positive at beginning of the study) had a sensitivity rate of 81.8% and a predictive power rate of 28.4% (predicting total work disability). These results are the best ever published for a spinal health indicator measured from a survey questionnaire. Besides acceptable predictive qualities, the combined indicator predicted work disability from predisability states. Its value for targeting interventions in industry aimed at preventing the worsening of early stages of spinal disorders toward disabling conditions, remains to be tested. (Key words: low-back pain, work disability, prediction, epidemiology)

The measure of prevalence of spinal disorders in different populations has shown variations that are intimately linked to the way spinal morbidity is defined. Annual prevalence rates of workers compensated for back injury have ranged from 0.3% to 1.7% in insured employed populations. Defined and measured from medical records, they have ranged from 2% to 9% in adult populations. The highest rates of spinal disorders came from health surveys in which participants were asked if they had back pain. Gynelberg reported annual prevalence rates ranging from 8% to 26% from a general health survey in a male 40- to 59-year-old population. Point prevalences in back symptom surveys have ranged from 17% to 31% and period prevalences (2 weeks to 3 months) from 19% to 43%.

Reported frequencies of spinal disorders increase in step-ladder fashion from compensation data to medical records and to health surveys. Information from compensated cases has shown variations according to the type of benefits and the presence or absence of litigation in the compensation process. Studies from medical records are susceptible to the type of health care available and the accessibility to health care facilities. Finally, self-reported pain and symptoms showed important variations with sex, type of occupation, and psychological factors. In the occupational setting, special attention has been paid to socioeconomic and psychological factors associated with back pain, its prevalence, and its clinical course. Work satisfaction, in particular, has been an indicator consistently associated with poorer health status and has been used liberally as a surrogate for other factors affecting health, such as a poorer socioeconomic status and use of tobacco and/or alcohol. Bigos et al. tried to study the relationship between work perceptions and reported back injuries in a large longitudinal study, which constitutes the most important contribution to date on the time relationship between psychosocial factors and self-reported acute back pain at work.

The present study tried to (1) measure the prevalence of spinal disorders defined by 10 health indica-
tors in a population of aircraft assembly workers and (2) compare the qualities of these indicators for predicting compensation, absenteeism, work limitation, and symptoms in a 12-month prospective observation period.

Methods

Study Population and Survey Method. The population studied consisted of all assembly workers having at least 1 year seniority in a large aircraft assembly plant. Their work consisted mainly of drilling and riveting metal parts, 80% of which are mounted on templates of various sizes. Self-administered questionnaires (French and English versions) were mailed to all assembly workers after they had been informed verbally of the study by their Union representatives. Questions were specific to four types of back health indicators.

1. Symptoms to the back in the week preceding the survey using descriptors related to duration, frequency, and quality from the McGill Pain Questionnaire.

2. The presence of any limitation in performing at work and in activities of daily living (ADL) in the preceding week, derived in part from the Oswestry questionnaire.

3. History of accident to the back and workmen’s compensation.

4. Health services/products consumption for a back problem in the preceding week.

In all, ten indicators were used. The question regarding limitation in performing at work was written as “Check the sentence that best describes your back in the last working week.” Answers were “My back did not bother me; My back bothered me in my work; My back kept me from doing my regular work; Because of my back I had to stay home at least one day.”

When responding to a questions regarding limitation in handling 25 pounds in the last working week, the workers were asked to respond using a five-point scale: “No limitation; Could handle only if at hand; Could handle only with back discomfort; Could not handle 25 pounds or more and could not handle 10 pounds or more.”

Limitations in ADL in the past week included any of the following: disturbances with sleeping and driving and reduction in time spent in sports and household activities because of the back.

The following variables were measured for their potential confounding effect using the Quebec health survey questionnaire: age, weight index (lbs/inch²), smoking, number of hours spent in sport or physical activities in past week, stressful life events in past year, and caring for children at home. Socioprofessional variables included number of overtime hours worked in an average week, seniority at the company and at the present job, boredom at work (job very boring; somewhat boring; or not boring at all), getting help when needed from foreman or coworkers (often; sometimes; or never), and work satisfaction toward either general working conditions, relationship with foreman, and relationship with other workers (very satisfied; moderately satisfied; not too satisfied; or not satisfied at all).

Twelve months after the first questionnaire, a follow-up questionnaire similar to the first was sent to the workers. During the interval, all cases of compensation and visits to the plant clinic for a back problem were obtained from the company computerized records. The study took place between October 1, 1989 and October 31, 1990.

Response Rate. The questionnaire was mailed initially to all 395 eligible assembly workers identified through the company personnel records, and 269 were returned completed. Of the 126 questionnaires not returned, 25 indicated refusal to participate. Among the 101 others, several were working overseas but the detailed reasons for nonparticipation were not known. Because the compensation status was available for all employees, it was possible to compare the payment rates between participants and nonparticipants before and during the 1-year study period (Table 1). The rates of compensation for the back as well as for all sites were very similar in both years and none of the differences was significant (P < 0.1). Of the 269 participants, 205 (76.2%) completed the 12 months’ follow-up questionnaire, 11 had left the company, and 53 did not respond. These 53 nonrespondents were more likely than the respondents to have been compensated for a back problem in the year preceding the study (20.8% versus 8.7%; P < 0.03), but not during the study period. Otherwise no statistical difference (P > 0.1) was observed between respondents and nonrespondents for mean age (36.8 years versus 38.7 years) and seniority at the company (10.4 years versus 10.8 years), and for initial prevalence of back symptoms (43.3% versus 39.1%), limitation at work (27.2% versus 31.2%), limitation in handling 25 pounds (36.7% versus 32.8%), limitation in ADL (28.1 versus 27.1), dissatisfaction at work (not too satisfied and not satisfied at all) (18.2% versus 18.5%), and smoking (51.5% versus 50.8%) and they were all male workers.

Table 1. Compensation Rates * for Back Problem: Comparison Between Participants vs. Nonparticipants and Respondents vs. Nonrespondents

<table>
<thead>
<tr>
<th></th>
<th>N 1988 (%)</th>
<th>1990 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>All Sites</td>
<td>Back</td>
</tr>
<tr>
<td>Refusals</td>
<td>25</td>
<td>28.0</td>
</tr>
<tr>
<td>No answer</td>
<td>101</td>
<td>31.7</td>
</tr>
<tr>
<td>Participants</td>
<td>269</td>
<td>29.2</td>
</tr>
<tr>
<td>Respondents</td>
<td>205</td>
<td>28.2</td>
</tr>
<tr>
<td>Nonrespondents</td>
<td>53</td>
<td>32.1</td>
</tr>
</tbody>
</table>

* Numerator = number of individuals compensated at least once in the interval.
† The year 1990 was truncated to October 31, the latest available revision, explaining the lower rates observed for 1990.
‡ Of the 269 participants, 205 responded to the follow-up questionnaire, 53 did not respond, and 11 had left the company.
§ Chi-square of the difference: P = 0.03.
Statistical Analysis. Initial prevalences for each of the 10 indicators were computed and changes during the follow-up year were described. The predictive qualities of each indicator at the beginning of the study period were computed in regard to four outcomes: occurrence of (1) compensation and (2) absenteeism for a back problem during the 12 months of the study, and the presence of (3) limitation in performing at work and (4) back symptoms at the end of the study.

Each of the 10 indicators and each potential confounder was first submitted to separate univariate logistical regression analysis with regard to each of the four outcomes using GLIM. Variables associated with one of the four outcomes were retained in the multivariate analysis. The log-likelihood ratio test was computed in a stepwise fashion to identify the indicators that were independently associated with one of the four outcomes while controlling for potential confounders. Odds ratios, with their 95% confidence intervals, were computed using the normal approximation.

For each indicator showing a statistical independent association with one of the four outcomes, predictive power

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Initial Prevalence (%)</th>
<th>Number of Workers Improving/Worsening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back symptom in preceding week</td>
<td>42.3 (112)</td>
<td>33/29</td>
</tr>
<tr>
<td>Back symptom persisting more than 24 hrs</td>
<td>22.7 (58)</td>
<td>30/42</td>
</tr>
<tr>
<td>Back symptom every day</td>
<td>24.4 (62)</td>
<td>43/41</td>
</tr>
<tr>
<td>Any limitation in performing work</td>
<td>28.1 (72)</td>
<td>27/20</td>
</tr>
<tr>
<td>Limitation in handling 25-pound material</td>
<td>35.7 (90)</td>
<td>36/34</td>
</tr>
<tr>
<td>Limitation in activities of daily living</td>
<td>29.4 (75)</td>
<td>17/17</td>
</tr>
<tr>
<td>Ever been compensated for back problem</td>
<td>38.4 (80)</td>
<td>—/16*</td>
</tr>
<tr>
<td>History of back accident in past 12 mo</td>
<td>7.2 (19)</td>
<td>—/19</td>
</tr>
<tr>
<td>Consumption of drugs in preceding weeks</td>
<td>11.9 (31)</td>
<td>15/9</td>
</tr>
<tr>
<td>Seen a health professional in preceding week</td>
<td>7.3 (19)</td>
<td>10/11</td>
</tr>
</tbody>
</table>

N values are in parentheses.
* Denominators vary slightly because of missing values.
† Work limitation consisted of 83.3% in nondisabling states in which workers declared being bothered by back symptoms but could do their normal job.
† Of the 16, 7 new cases not previously compensated (N = 269).

Figure 1. Calculation of sensitivity and predictive power. (positive predictive value) and sensitivity were computed to describe their clinical significance (Figure 1). The predictive power is the proportion of individuals positive for an indicator who will have back problems 1 year later and sensitivity is the number of those with later back problems who could be identified at the beginning of the study.

• Results

Initial prevalence of spinal health indicators.

The prevalence of any kind of back symptoms in the week preceding the survey among the 269 workers enrolled was 42.3% (Table 2). The lower back represented 72.5% of those and descriptors mostly used for the worst symptom were “dull or aching pain” (30.9%), stiffness (21.6%), “shooting or stabbing pain” (14.4%), and “burning” (12.4%). Descriptors mostly used for least severe symptoms were “fatigue” (36.5%), “stiffness” (24%), and “weakness” (14.4%).

One half of the workers reporting back symptoms in the preceding week had symptoms for at least 12 months (median). The prevalence of symptomatic workers with episodes persisting for more than 24 hours was 22.7%, and for episodes occurring almost every day the prevalence was 24.4%. Conversely, of the 112 symptomatic workers, 44.2% had short episodes (with relief within 24 hours) and 52.6% had their symptoms once a week or less often.

The prevalence of a limitation of any kind in performing at work was 28.1%, which was distributed primarily (60 of 72) in the category “bothered” while not kept from doing their regular job. Only 12 workers declared themselves unable to perform their normal job. Of the 112 symptomatic workers, 35.2% reported no interference with the performance of their job and 44.7% reported no limitation in handling 25-pound loads. The prevalence of any limitation in activities of daily living was 29.4%, with sleep disturbance the most commonly reported.

In the study population, 30.4% were compensated previously for a back problem at least once in their lifetime, of which one fifth (5.9%) had occurred in the previous 8 months. A history of accident to the back in the previous 12 months was reported by 7.2%. History of compensation and accident to the
back were more frequently reported among currently symptomatic workers, with odds ratios of 2.0 (95% confidence interval, 1.2 to 3.6) and 3.0 (95% confidence interval, 1.2 to 7.3), respectively. On the other hand, 51.4% of the 112 symptomatic workers reported no previous history of compensation, absence from work, or visit to a health professional for a back problem, and therefore would not be identified by medical or compensation records or otherwise than by a prospective survey.

Changes in Spinal Status at the End of the Study
Changes in each indicator for the 205 respondents to the follow-up questionnaire showed a turnover with a similar number of workers improving and worsening in the 12-month interval, therefore not greatly affecting the prevalences, except for the indicator "symptoms persisting more than 24 hours," for which 42 individuals worsened and 30 improved (Table 2). During the study period, 16 (6%) of the initial 269 participants were awarded 17 compensated episodes for a back problem, of which 7 were first-time awards. The rate of visit to the plant clinic for a back problem was 13.4% (36 of 269).

Potential Confounders—Univariate Analysis
Of the variables used to control for potential confounding, the following showed no association with any of the four outcomes in univariate analysis: age, weight index, number of hours spent each week in sport or physical activity, seniority at the plant, number of hours worked overtime, and boredom at work. Tobacco use and work satisfaction were both associated with all outcomes, except compensation, with odds ratios ranging from 2.0 to 2.5 and for work satisfaction from 3.1 to 8.6 (all 95% confidence intervals, excluding unity). Caring for children at home was associated with limitation in performing at work, with odds ratios of 2.3 (95% confidence interval = 1.1 to 4.6); stressful life events in the past year was associated with back symptoms, with odds ratios of 1.8 (95% confidence interval = 1.0 to 3.1). The following results from the relationship between the initial spinal health indicators and the spinal status 12 months later were all adjusted for those potential confounders in the multivariate regressions.

Predicting Compensation for Back Problems
Two initial spinal health indicators performed equally in predicting compensation for back problems in the 12-month follow-up: (1) limitation in performing at work and (2) history of previous compensation for the back, but only the former was independently associated with compensation, with an odds ratio of 3.0 (95% confidence interval = 1.0 to 9.3) (Table 3). That indicator detected 53.3% (sensitivity) of the 16 individuals who would later be compensated and had a predictive power of 11.1%.

Predicting Absenteeism for Back Problems
The best indicators for predicting absenteeism for a back problem in the year of follow-up were (1) limitation in ADL, (2) history of ever having been compensated for back problems, (3) back symptoms persisting more than 24 hours, and (4) limitation in performing at work. All four were significantly associated with the outcome but only the first two showed an independent association with absenteeism, with respective odds ratios of 4.3 (95% confidence interval = 1.0 to 19.2) for limitation in ADL and 5.5 (95% confidence interval = 1.9 to 15.9) for history of compensation. The two indicators detected 67.9% and 64.3% of absenteeism, respectively, and the predictive powers were 32.8% and 32.1%, respectively.

Predicting Limitation at Work
Two initial indicators were independently associated with a limitation at work at the end of the study period: (1) limitation at work at the beginning of the study (odds ratio = 3.5; 95% confidence interval = 1.3 to 9.9) and (2) limitation in handling 25-pound loads (odds ratio = 1.7; 95% confidence interval = 1.1 to 2.6). The former showed the best overall performance, detecting 62% of individuals with the outcome and having a predictive power of 59.6%. This indicator, being a good predictor of itself in a later reassessment, is indicative of good reliability.

Predicting Back Symptoms
The two best indicators predicting back symptoms at the end of the follow-up period were "back symptoms" and "back symptoms persisting more than 24 hours," the latter showing an independent association with the outcome (odds ratio = 1.5; 95% confidence interval = 1.1 to 2.1). This seems to indicate that persistent symptoms, rather than transient symptoms, are a better indicator for predicting the recurrence or the maintenance of a symptomatic state 12 months later. None of the indicators based on symptoms were predictive of a functional limitation expressed by the other three outcomes (compensation, absenteeism, or limitation at work), supporting the theory that functional limitations result from the interaction of several factors, of which back pain is only one.

Predicting Total Work Disability
Of the 205 respondents, 33 (16.1%) were completely disabled from work (compensated, absent from work, or both) during the study period. Three initial indicators independently predicted one of the two outcomes: limitation in performing at work, limitation in ADL, and history of compensation (Table 3). The combination of those three (either one positive in an individual at the beginning of the study) could detect 81.8% (sensitivity) of the 33 later showing a total work disability, and had a predictive power of 28.4%, a performance that was superior to any of the three
Table 3. Predictive Qualities of Initial Spinal Health Indicators with Regard to Spinal Status 12 Months Later

| Initial Indicators | Compensation | | Work Limit | | Symptoms | |
|--------------------|--------------|--------------|--------------|--------------|--------------|
| | S | P | S | P | S | P |
| Back symptom persisting more than 24 hr | — | — | — | — | 40.7 | 80.4 |
| Limitation in performing at work | 53.3 | 11.1 | 62.0 | 59.6 | — | — |
| Limitation in handling 25-pound material | — | — | 64.0 | 47.1 | — | — |
| Limitation in activities of daily living | — | — | 67.9 | 32.8 | — | — |
| Ever been compensated for a back problem | — | — | — | — | 64.3 | 32.1 |

OR, odds ratio; S, sensitivity; P, predictive power. Values in parentheses are 95% confidence intervals.

Odds ratios and 95% confidence intervals obtained from a logistic regression after adjustment for the other initial indicators and the co-variables showing an association in the univariate analysis.

indicators individually. Of these three indicators predicting total work disability, two consisted of actual predisability stages of back problems: of the 72 reporting a limitation in performing at work, 60 (83.3%) had a limitation that did not prevent them from performing their usual tasks at work. Of the 90 reporting a limitation in handling 25 pounds, 74 (82.2%) had a limitation that did not prevent them from handling such weight.

- Discussion

Despite the small number of subjects in this study, the observed frequency of spinal problems, according to different indicators, conformed with the stepladder configuration previously reported of increasing figures from annual incidence of compensation (6%) to the 1-year prevalence of symptoms to the back (42.3%). Initial prevalence rates were obtained from 269 of 395 eligible assembly workers at the plant. In the most extreme cases, in which all nonparticipants had no back problems, the prevalence of symptoms in the preceding week would decrease to 28.4%, which is still among the highest rates reported in the literature.2,14,15,29,30 Such a scenario seems improbable because nonparticipants had back compensation rates that were very similar to those of participants. In terms of the representative nature of the study population, the other spinal health indicators measured did not depart greatly from those observed in other occupational groups. The duration of symptoms among symptomatic workers was long (median 12 months) and was comparable to that reported by Bergenudd et al.2 Our prevalence of symptomatic workers reporting "symptoms every day" (24.4% or 47.4% of the symptomatic workers) was comparable to that reported by Svensson30 in a male 40- to 47-year-old population, but was lower than in nurses14 and higher than in a Finnish 30-year-old male population.15 Our prevalence of limitation in the performance at work compared with that reported by Svensson31 and Harber14 but was lower than in a population of miners described by Lloyd.23

The duration of follow-up was only 1 year, and this short period was sufficient to show a great deal of turnover in each indicator, illustrating the evanescent nature of back problems. In most of the indicators, one third to one half of workers reporting back problems initially improved and an equal number of individuals worsened in the follow-up year. Among the 205 respondents to the follow-up questionnaire, the annual prevalence of back symptoms, defined as the initial prevalence plus the number of initially asymptomatic workers reporting back symptoms at the end of the study, was 66.3%, a number close to the lifetime prevalence rate reported by Svensson et al.30 but here observed only during a period of 12 months. When these observations on back problems were examined in light of several health indicators and in a longitudinal fashion, the term "lifetime prevalence" appears to be a misleading conception of back disor-
ders because what is observed primarily are recurrences of a problem that actually began in the early years of productive life. The dynamic nature of this health problem, which has been well recognized, seems perfectly fit for more aggressive secondary prevention interventions to reduce the number and duration of recurrences in individuals who have already suffered from back problems.

To that extent, our composite indicator had acceptable predictive qualities, with regard to subsequent total work disability, for targeting workers who would benefit the most from a secondary preventive approach, that is, health promotion and corrective ergonomics. An advantage of the indicator was to join disability for a period of 12 months. The utility of an approach, that is, health promotion and corrective interventions to reduce the number and duration of productive life. The dynamic nature of this health problem, which has been well recognized, seems perfectly fit for more aggressive secondary prevention interventions to reduce the number and duration of recurrences in individuals who have already suffered from back problems.

In conclusion, we described a combined spinal health indicator, based primarily on predisability stages, that can reasonably predict total work disability for a period of 12 months. The utility of such an indicator to prevent spinal disorders in industry remains to be demonstrated. We are now planning an intervention combining a back health maintenance program and the analysis of worker's perceptions of back constraints at their work stations. The intervention would be reserved for those identified through the combined indicator and the utility would be measured in terms of evolution toward any period of total work disability.

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