Journal of Occupational Rehabilitation, Vol. 15, No. 4, December 2005 (© 2005)
DOI: 10.1007/s10926-005-8028-x

Prognosis and the Identification of Workers Risking Disability: Research Issues and Directions for Future Research

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Introduction: *Screening procedures based on prognostic data are an important prerequisite for prevention of disability due to low-back pain. This paper reviews the research on prognosis to delineate the most pertinent research challenges, and outlines directions for future research to improve the scientific quality and screening accuracy of prognostic efforts.* Methods: *Reviews of prognosis research were examined to identify key methodological and research issues.* Results: *Certain issues such as sampling procedures, research designs, data analyses, prognostic indicators, and follow-up procedures limit the value of prior studies. Absence of a clear conceptual framework hampers interpretation of findings and moving research questions forward. The recurrent nature of back pain and the need to effectively include the impact of employer actions and the job market were also identified as significant issues.* Conclusions: *Future research will be enhanced by addressing conceptual and definitional issues, applying tested and sensible measures, and careful follow-up of the study population.*

KEY WORDS: screening; disability; conceptual models; methodology.

INTRODUCTION

Musculoskeletal conditions involving the back, the upper extremities, or the neck, are very prevalent in the workplace. Even though only a small minority of workers with such conditions experiences long-term work incapacity, they represent the majority of the associated health and disability burden (1–3). An elusive goal when managing these

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conditions is preventing long-term disablement through targeted interventions. A basic assumption for preventive interventions is the ability to identify early on those at risk of developing long-term work disability, so that limited resources may be directed to those most in need, before the problem becomes intractable. If targeted intervention can effectively prevent prolonged disability, then knowledge about prognostic factors is essential.

The aim of this article is to identify key research issues in order to advance the science of disability prognosis and subsequent targeted interventions. We focus on common back pain and its associated disability (4). Moreover, we discuss the complexities of prognosis in the context of recurrent episodes of back pain. A review of current research on risk screening and associated theoretical, methodological, and logistic issues is presented. Goals for research and strategies for improving upon current methods are presented. Although the purpose of screening may differ in various settings, we focus on modifiable prognostic factors that can direct preventive interventions.

OVERVIEW OF THE RESEARCH

A number of scientific reviews have examined the research on prognostic factors for back pain and related disability. Table I provides a synopsis of the issues examined while Table II is a summary of selected reviews, listing the methodological issues that each addresses. These reviews include a large number of studies and variables related to disability outcomes, and draw similar conclusions, even if the nuances are admittedly different. The multidimensional nature of the problem is evident based on the variety of

Table I. Methodological Issues in the Prognosis Research Field

Issue	Definition
Sampling	Strictly outline inclusion/exclusion criteria
	State enrollment time point clearly
	For many questions, clear, early enrollment is necessary (<3 weeks following onset)
	Representative sampling techniques (random selection or consecutive cases)
Design	Prospective, inception cohorts required or RCTs
Prognostic indicators	Strictly define constructs of measure
	Selection should flow from conceptual framework, recognizing the multifactorial nature of the problem
	Use standardized, psychometrically sound instruments
Analysis	Multivariable techniques to adjust for all potential confounders
	Avoid overfitting the data (too many covariates for sample size)
	Prospective validation in homogenous cohorts required
Follow-up	Strictly define outcome(s) of interest
	Adequate duration of follow-up (years)
	Strive for >80% follow-up rate
	Patterns of attrition should be investigated to determine if they are random or systematic.
	Blinded outcome measurement with standardized, psychometrically sound instruments
Conceptual framework	Strictly define the construct of the problem being studied
	Account for the recurrent and multifactorial nature of back pain disability
	Overarching theory requires identifying specific hypothesized relationships between variables
	Broaden the view to include factors outside of the usual professional/discipline boundaries

Table II. Summary of Methodological Issues Raised in Current Reviews of the Literature[a]

Review	Sampling	Design	Prognostic indicators	Data analyses	Follow-up	Conceptual framework
Crook *et al*. (5)	X	X	X	X	X	
Hoogendorn *et al*. (6)			X	X		X
Linton (7)	X	X	X			X
Linton (8)	X	X	X			X
McIntosh *et al*. (9)	X	X		X		
Pengel *et al*. (10)	X	X		X	X	
Pincus *et al*. (11)	X	X			X	
Shaw *et al*. (12)	X		X	X		
Valat *et al*. (13)		X	X			
Waddell and Burton (14)	X	X	X			X
Wasiak (15)	X		X		X	X

[a] See Table I for a description of the methodological aspects.

risk factor domains including medical (e.g., radiating pain, images), background (age, sex, smoking status), work place (e.g., heavy work, job satisfaction), psychological (e.g., depression, fear of pain), social (e.g., social support, breadwinner status), and system factors (e.g., insurance policies, legal claims). Certain prognostic factors are consistently related to outcome such as fear-avoidance beliefs, work conditions, depressed mood, and a previous history of back pain. The biopsychosocial model (4,16,17) is frequently employed in this research and cited as a unifying theory to explain outcomes (18).

Several promising screening instruments have been used to identify those at higher risk of subsequent disability (5,14,19–21), but it is not clear whether predictive accuracy is sufficient for efficient clinical application. Only modest accuracy is achieved even with detailed screening instruments and multivariable prediction models (14), at best, 70–80% sensitivity and/or specificity for long-term disability after a single screening evaluation. With these test characteristics, many participants would be erroneously categorized. Expanded screening modules result in only minor improvement in the total variance explained. However, this is not unexpected—only modest predictive accuracy has been achieved for catastrophic outcomes such as death from carcinoma or myocardial infarction, fields in which years of rigorous research has been conducted, identifying numerous significant risk factors (22–25). The false positive rate when attempting to predict onset of coronary heart disease is comparable to the accuracy rates in back pain prognosis (26). On the other hand, even small improvements in the accuracy of screening for disability are of critical clinical and economic importance (27–29).

Nevertheless, some enhancements may improve overall predictive accuracy and increase the effectiveness of subsequent allocation of interventions. To this end, the scientific reviews of the literature on prognostic factors in Tables I and II provide a framework for evaluating common methodological challenges as presented below.

METHODOLOGICAL ISSUES

The Purpose and Model Employed

A clear conceptual model of how back pain disability develops is essential in determining which factors should be addressed, at what point in time, and for whom, thereby

producing the maximum impact. Divergent findings from apparently similar studies may occur if there are differences in the underlying models of disability. This can lead to a different focus for risk determination and ultimately selection of different potential risk factors for investigation.

In identifying prognostic factors for disability the typical study population is comprised of workers. The data source varies, but the primary outcomes are work-related, such as return-to-work rates, or changes in benefit status. Work retention studies have usually investigated the risk of future absence. One approach, based on an underlying biomechanical model linking physical demand (as a hazard) with biomechanical strain (as a harm), has focused on reducing the risk of injury caused by ergonomic and biomechanical factors. More recently there has been an increasing focus on the psychosocial work environment (as a potential hazard) with a range of indicators of harm such as work stress, work absence (and work disability status) and on workers' perceptions of work (30). In terms of risk factors, this shift in the *underlying* model of disability has led to investigations of new types of potential risk factors and this in turn has led to the identification of different prognostic factors and the possibility for the design of different intervention strategies. Studies may integrate various models and thereby include a variety of physical, psychological and social variables.

An Empirical Approach: Actuarial Models

A central issue in screening is the accuracy of predicting future disability based on various initial data sets. Historically, prediction has been based either on a *clinical* judgment made by a practitioner, or on other empirical evidence using some statistical or mathematical formula or cut-off points. The empirical approach has been called *actuarial* (31,32), and because of its empirical base this model offers the promise of improved accuracy (33–35).

In this context, the *actuarial model* is based on research evidence that allows the predictors to be quantified and combined following a set of empirically supported rules. Such an approach lends itself to wide administrative applications. The exact nature of the predictors is relatively unimportant, but their strength in terms of accuracy of prediction is critical. There is no inherent ordering of variables in terms of the significance and many different types of predictors may end up as part of the optimal algorithm, as the selection is based on each variable's contribution to the prediction of outcomes such as duration of disability, return to work, or costs.

There are some inherent difficulties associated with the empirically based *actuarial model*. First, it assumes that the variables are stable and static (31). Second, there is no room for individual differences as the same statistical formula is always used, leading to misclassifications. Third, the actuarial approach is problematic when critically important salient data are not collected. Fourth, the utility of a strictly actuarial model is limited when the ceiling for predictive accuracy is relatively low (32) and when the underlying evidence is weak. In addition, the generalizability of such statistical prediction models to other populations and contexts is often unknown. Lastly, since prediction is the driving factor, the modifiability of the risk factors may be of secondary importance. Therefore, actuarial models may not be easily translated into secondary prevention applications.

Another risk identification model is based on "flagging" (36,37), and it appears to be a methodological compromise between the inflexibilities of a purely actuarial model and a purely subjective approach based on clinical judgment. There are three important features of the "flags" (38). First, it offers a "systems perspective" and assumes that an adequate understanding of the problem requires consideration of both the injured worker and the individual's social and occupational context. Second, it contains both clinical and occupational elements. Third, it makes an important distinction between the individual's perception of the situation and the objective features. Flagging systems can be empirically informed with respect to the selection of risk factors (flags). It is also clinically oriented as it emphasizes modifiable risk factors and may lead to attempted classification of types of individuals with respect to prognosis and targeting interventions on an individual basis. There is also emphasis on the comprehensiveness of the predictors. Overall, a multiflag approach lends itself flexibly to both individual clinical decision-making and wide-scale system applications. However, its predictive accuracy in administrative applications will likely be lower than one arising from a purely statistical or "actuarial" approach and will likely result in overidentification of individuals at risk.

Ultimately, there appears to be a continuum of predictive decision rules ranging from gut feelings in the clinic to advanced statistical algorithms. Different models may have varying degrees of empirical support as well as varying balances between sensitivity and specificity, and different relevance for application. Any variable may be a valuable predictor, so the first stage of model building may include a broad epidemiological sweep. The identification of predictors however is only a first step. For risk assessment in the context of clinical application, there is a need to be able to apply the model on an individual level with a view on utilizing the screening technique to improve the results of intervention.

The Need for Broader Conceptualization

The different models used by clinicians, economists, and epidemiologists to study work disability related to back pain give little attention to the role of the employer as an influence on outcomes. Economic models are based on the theory of labor supply, in which a potential worker faces tradeoffs between nonwork time and time at work subject to constraints (e.g., physical function), and influenced by incentives (e.g., compensation benefits vs. wages) (39).

A significant gap in all models is the *absence* of an adequate conceptual framework from which to predict the behavior of employers (40). The decision as to whether a person with back pain remains at work, or returns to work following an absence, is jointly determined by an employer, the worker, and others (e.g., the family and health care providers). The existing models, however, are essentially based on the characteristics of *workers*, and the health care services they receive. Fortunately, a refreshing exception is the inclusion by some studies of the effects of job accommodations (41,42). A broader conceptualization would offer the opportunity to include "new" variables that might substantially improve our ability to predict, and might also improve interventions since they would provide more accurate analyses.

A second broadening of the conceptual model is the recognition that the boundaries between occupational and nonoccupational back pain are more institutional and legal rather

than clinical. It would be more informative to conceptualize back pain as a *developmental process* affected by a variety of factors, than as an "occupational" injury caused by a specific accident.

THE TIME FACTOR

There are a number of methodological concerns involved in capturing the time factor. We focus on the issues of recurrence and measurement. Traditionally, episodes of work-related musculoskeletal disability were conceptualized as originating at the time of an injury, followed by an intervening period of incapacity or work loss, and finally resolution or return-to-work. Survival analysis was the optimal research analytic strategy as it allowed tracking of the entire time course of recovery to be tracked, as shown in Fig. 1 (43). Time between injury and the outcome of return-to-work was often used to describe participants' work incapacity experience (44). This conceptual view supported efforts to categorize duration of disability using the terms acute, subacute, and chronic, with various cut-off points (45). Recently, there is growing recognition that musculoskeletal disability often does not fit these patterns of recovery.

Time to return-to-work is an ambiguous outcome indicator as some individuals return in a modified capacity while experiencing ongoing difficulties and symptoms, whereas others return to full duty. Administrative outcomes of time-loss indemnity benefits and claim closure can underestimate the true duration of disability (46). The *first* return to work is a questionable marker of recovery because a significant proportion of workers experience a recurrent absenteeism episode (47). While a prognosis for initial return-to-work is very positive, rates of recurrence depend on the definitions of recovery and recurrence used, and wide ranges have been reported (between 4 and 73%) (10,15). Figure 2 graphically portrays the recurrent nature of disability between two different occupations within the same hospital, and how the relative proportions of disability change over time. Clearly this picture cannot be captured adequately by a survival curve (Fig. 1). Defining recovery as whether a

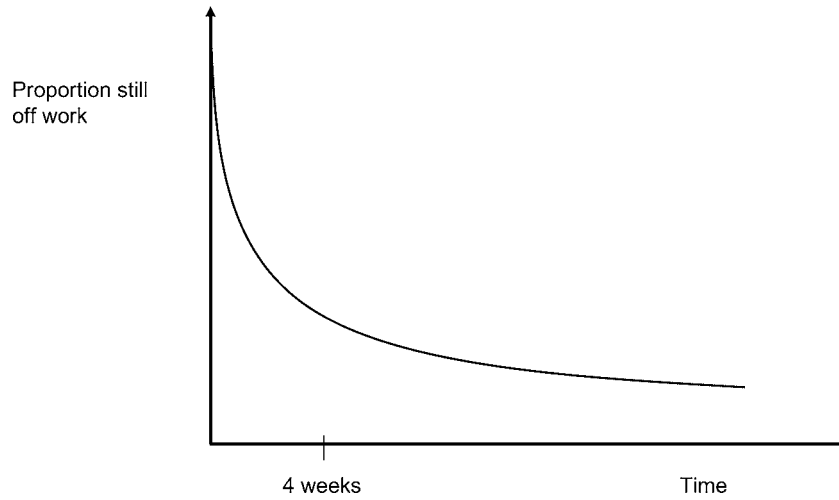

Fig. 1. Kaplan–Meier Curve of time on benefits.

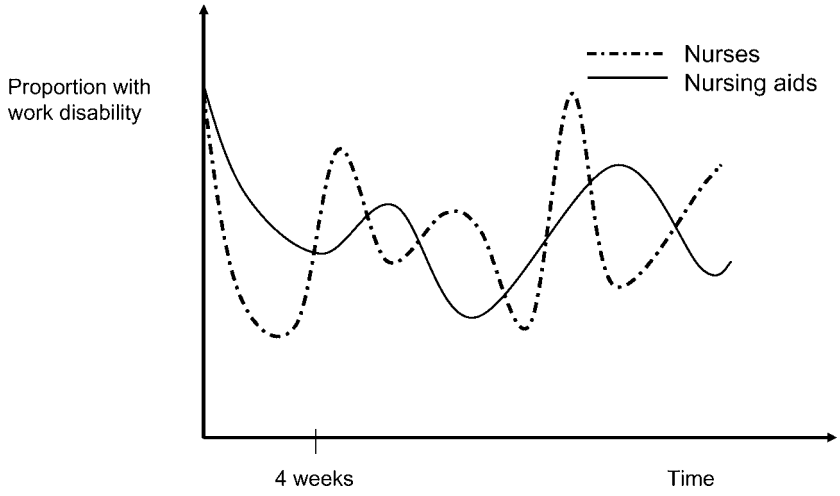

Fig. 2. Work disability by occupation.

subject is working or receiving benefits at a given point in time ignores the clinical reality of repeated incapacity episodes. Some research has been done on defining what constitutes a recurrent episode (15), however, further research is needed on defining a successful return-to-work outcome and on identifying the most appropriate analytic strategies for modeling recurrence. Additionally, while a history of previous episodes appears to put individuals at higher risk of future problems (48), it is unclear how serial episodes of musculoskeletal disability are related. Repeated episodes of pain and disability in the same body region may be manifestations of the same underlying physical anomaly that is being repeatedly aggravated. Alternately, each episode may be distinct, and other contextual factors in a person's life may create a higher risk of recurrent problems.

Our emerging understanding of the recurrent nature of work-related musculoskeletal conditions has important implications for prognosis. Even in a first claim for LBP disability, the patient may have had multiple LBP episodes that affect his or her beliefs, ability for work, and scores on prognostic screening tests. If early intervention strategies are not appropriate for those with multiple previous episodes, they may have poorer clinical outcomes. Prognosis could be linked to effective targeted interventions if *causal* factors leading to poor outcomes and recurrence can be determined.

In addition to difficulties arising from the recurrent nature of musculoskeletal disability, time-dependency is often observed when prognostic factors are considered over a time period. Time-dependency arises when variables change in value over the duration of the problem (43,49). For example, while episode duration and amount of health care utilization for a compensable back pain condition appear to be predictive of delayed recovery, these variables change in magnitude over time (5,48). Periodic measures of time-dependent covariates are needed over the course of the clinical condition. In addition, researchers must be careful that the time-varying nature of the predictor is not a function of the outcome of interest. For example, the healthcare utilization (type and intensity of care) for back pain will likely vary during the course of an episode. However, the need for future health care is related, in part, to the outcome (failure to recover or return to work). Therefore, when

considering time-varying predictors, it is important that the "period of exposure" be clearly defined and consistent across participants.

Another feature of time-dependency arising less frequently are indicators that change in predictive value over time. One example is the observation of leg pain being predictive of delayed recovery only for the first few months of a low back pain problem (9). Measurement itself may influence outcomes (50) by leading to efforts to address a particular risk factor. After this period, the presence of leg pain does not appear to be as important a predictor. To account for these issues, longitudinal studies with periodic re-assessment of prognostic indicators are needed (51).

The Importance of Defining the Population

Recent evidence shows that the course of LBP and prognostic factors for recovery vary significantly across populations (9,52,53). Although some of this variation may be explained by selection and measurement biases, the body of evidence suggests that population characteristics do have a significant influence. This may explain, in part, why conflicting evidence about prognostic factors is often reported in systematic reviews (14).

Surprisingly, a clear description of "*who is studied*?" is commonly omitted from the design and reporting of prognostic studies (12,40,54). Providing answers to *"who, when and where?"* is necessary to establish the internal validity of a study because factors that influence selection, participation, and attrition can easily influence results. Because health recovery and return to work from an episode of back pain depend on complex relationships among individual, clinical, workplace, compensation, and societal determinants, it is also imperative to consider how determinants interact (9,52,55,56). Conceptually, this is vital to disentangle prognostic pathways that have to date remained elusive.

The source population is defined by the methods used to select the participants that form the study sample (57). When defining a source population, researchers should clearly describe *"who is studied?," "where is the study taking place?"* and *"when is the study conducted?."* Answering these questions provides a framework to define the "population at risk" for a study and is necessary to make inferences from the study sample to the source population. For example, if the purpose of a study is to describe the course of low-back pain, we might form an inception cohort by recruiting all Toronto hospital workers with a new episode of back pain during an accrual period. To document the episodic nature of back pain, we would follow workers for the duration of the study (no censoring) and observe how they transit among health outcomes (e.g., resolution, improvement, aggravation, persistence, and recurrence) over time. In the absence of selection bias, the number of workers with each health outcome would be used to compute the incidence rate of the various outcomes in the source population.

The primary goal of prognostic research is to understand causal mechanisms or prognostic pathways in a defined source population. Because demonstrating representativeness involves an arbitrary process (typically demonstrating that differences in the distribution of characteristics are not statistically significant) based on the comparison of the source population and study sample, it may provide a false sense of security about the validity of the sample and hide potential selection biases. Moreover, efforts to reach representativeness may compromise the validity of results by introducing selection bias or by ignoring effect modification that results from mixing subpopulations with different risk profiles.

Selection Bias and Effect Modification: Why Worry?

Selection bias arises from factors that influence subject participation and attrition. In prognostic studies, pain and disability themselves may directly influence willingness to participate and remain in the study. While comparing participants and nonparticipants may assist in determining whether participation and attrition is random or systematic, it provides little information about the association of interest in participants versus nonparticipants. Moreover, a high follow-up rate (more than 60%) does not ensure that attrition bias is absent (58). Trying to understand nonparticipation and attrition behaviors may be extremely challenging, but especially important in prognosis studies. One useful framework for addressing selection bias has been described (59).

Effect modification refers to the situation where the effect of one variable on an outcome changes over values of a third variable. The concept of effect modification is central to the study of the prognosis of low-back pain because its course and the effect of its prognostic factors vary according to individual and environmental factors. This reality demands that we conceptualize, a priori, how the course or the effect of prognostic factors will vary between populations and within subpopulations. If we refer back to our hypothetical cohort study of physical job demands and sustainable return to work in hospital workers, we can hypothesize (based on previous studies, qualitative data and clinical knowledge) that the effect of physical job demands on sustainable return to work will vary across levels of job control. Failure to recognize the potential effect modification of job control will result in a pooling of effects and can potentially invalidate results. This problem may be especially important when strong effect modification is present because weak effects in one level of the effect modifier can be distorted by the strong effect in another level. For example, the pooled results of our study may suggest a strong positive association between physical job demand and sustainable return to work (RR = 2.5). However, an examination of the effect modification of job control shows that the association is very strong for low job control (RR = 3.4) and weak (RR = 1.1) for those with high job control. The pooled effect, a function of the distribution of participants, would have falsely identified an effect in those with high job control when only a very weak one exists. Thus, selection bias and effect modification must be attended to when designing a prognostic study.

The Importance of Measurement

Two types of measurement issues need more attention. First, researchers must ensure that the methods used to measure prognostic factors, confounders and outcomes meet basic psychometric properties. The instrument should be reliable (yield reproducible measurement), valid (measure the construct of interest), and responsive (detect minimally clinically important differences). Because it is practically impossible to design perfect measures in this field of research, researchers will always have to contend with measurement error. However, it is critical that the measurement error be *nondifferential* (similar) across participants with and without a prognostic factor. While nondifferential error will still introduce bias, its direction is predictable and will tend to attenuate the strength of association between a predictor and the outcome. On the other hand, *differential* measurement bias occurs when the error associated with the measurement of the prognostic factor varies across

predictor groups. This effect of differential error is unpredictable and may lead to under- or overestimation of the strength of association.

Is There a Connection Between Risk Reduction and Outcome?

The traditional approach to prevention is to first screen for causal risk factors and subsequently to prevent ill health by removing these risks. Screening procedures might identify what interventions should be employed (14,60). Yet for LBP, the evidence for reducing known risk factors to decrease subsequent disability is poor. For example, efforts to prevent disability by reducing ergonomic risk factors such as lifting and heavy work have seldom produced the expected results (61). Further, although the assumption is often made that "early" interventions are more effective than the ones provided later on, there is relatively little research evidence directly testing this, and the recurrent nature of the problem makes the concept of "early" problematic.

A few investigations have employed a one-time screen of workers and subsequent intervention targeting risk factors included in the screening. Von Korff *et al*. (62) screened workers with back pain seeking primary care for activity limitations and then randomized consenting participants to a control group or a brief, individualized program designed to decrease fear and increase activity. At the 2-year follow-up, intervention produced sustained reductions in fears, activity limitations, and reported days missed from work. Similar results have been obtained in other studies (27,63,64).

For several reasons, reductions in well-known risk factors may not result in improved outcomes. The risk factor may simply not be causally linked to disability. For example, depression may be correlated with disability, but both depression and disability may be caused by a third variable (pain). Reducing depression may have little or no effect on disability. Similarly, the relationship between the risk factor (predictor) and disability may be mediated by other variables. Depressed mood may increase disability, but only under certain conditions (e.g., if the pain problem has persisted more than 3 months). Thus there is a need to have a clear model of how the risk factor affects work disability. Clearly, predicting disability is not the same as providing an effective intervention to prevent it. To achieve the promise of early (compared to usual current routines) identification and intervention we must understand better why persistent disability develops.

Many attempts at reducing risk factors have lacked a clear theoretical or conceptual framework and therefore have not been adequate tests of risk factor reduction (7). For example, convenience studies conducted with the goal of reducing disability in a particular work place may initiate a program to "increase job satisfaction" but with no clear model of how satisfaction influences disability, or with results that are difficult to interpret. "Job satisfaction" may well share variance with work demands, social support, stress, anxiety, and work latitude. Finally, very few studies report a check of the independent variable to ensure that the risk factor has truly been reduced or eliminated. Without such checks (was job satisfaction actually increased?) it is not possible to know whether poor results occurred simply because the factor was not adequately addressed (7,65).

Transferring Prediction Research into Practice

There is a real need to encourage an evidence-based approach to screening in its practical application. Major "system" stakeholders in disability, (i.e., the healthcare system,

the employer, the government, and the insurance or compensation system), appear to agree on the need for prognosis evaluation based on a biopsychosocial model. Further, stakeholders are interested in applying this evaluation to prevent disability. However, each one of them faces major challenges to the application of the best evidence.

Government-based disability systems, healthcare, and insurance or compensation systems are traditionally based on the biomedical model and do not systematically collect, recognize, and account for psychosocial variables in their data collection systems. Legal considerations, such as privacy and antidiscrimination legislation and practices are often cited as prohibiting the collection of such data. Moreover, the demographic and clinical variables collected by these systems via administrative databases are of limited use for disability prediction. Importantly, psychosocial variables are conspicuously missing in these databases (66).

The employer, another key stakeholder in disability, has the potential for effecting major changes in disability rates (67) but has limited access to evidence-based best practices in occupational disability. Despite legislative advances such as the Americans with Disabilities Act in the United States, or the Employment Equity Act in Canada, employers have not yet been provided with adequate tools to implement effective and proactive disability management practices concerning job accommodations that are of critical importance with individuals at high risk for disability (5,68,69).

Another possible dilemma in transferring prognosis research into practice is overidentification of individuals at risk. Because a large number of the risk factors (dealing with almost any adverse life or work event) have been isolated, some applications may have high rates of "false-positives." Depending on the intervention tied to the screening procedure, this may lead to dire consequences for the stakeholders.

Finally, transfer applications pose a particular challenge concerning competency (69), in clinical and medicolegal contexts. Those applying the predictive models may not have an understanding of the scientific principles involved. As underscored above, this could result in numerous problems that might greatly compromise the instrument's accuracy and integrity. Consequently, a challenge is to effectuate transfer so that the methods are applied accurately and appropriately.

Summary and Recommendations

The research to date has made a solid contribution to our understanding of why back pain may result in disability. Based on this knowledge, some brave attempts have been made to identify early on those who may develop persistent disability in order to enable preventive interventions. Initial results have been encouraging, but have also highlighted the difficulties of accurate identification and the matching of an intervention. Moreover, the use of such programs is not widespread and advances are needed to improve effectiveness. This review suggests that in order to increase our knowledge and significantly improve screening techniques, future efforts need to solve certain methodological problems.

Let us start with some important methodological features that might improve future studies. A summary of these is shown in Tables I and II. First, considerable work is needed to develop and clarify the conceptual framework. This is a vital and necessary first step because interpretation of the research is dependent upon it. In fact, without a conceptual model, investigations may well lack an adequate test of the risk factor or be unable to interpret what the results actually mean. Thus, it may be impossible to determine if the

factor is causally linked to outcome and thereby determine which interventions might be appropriate for prevention.

We have underscored the need to not only clearly describe the framework, but also to expand its scope. Indeed, we believe that the biopsychosocial model is too narrowly defined. A consequence is that important factors that may significantly improve our understanding of the development of disability and thereby its prediction are ignored. To further our understanding it is essential to incorporate socio-demographic, clinical, and occupational factors. Even broader issues such as employer reactions, the job market, and family variables, appear to be important but seldom included. At the same time, we believe that more effort should be focused on modifiable risk factors and that these should be clearly tied to interventions targeting them. Indeed, an exciting development may be multimodal, multisystem, and multimethod models.

Prediction might be improved if a model could be developed that included employer behavior in the framework of back-related disability. This would complement the current models that almost exclusively address the worker. A further step would be to develop a conceptual model of the influences that determine how employers deal with work absences. This might include the effects of what the firm has invested in the worker, "firm-specific capital," as well as differences in economic incentives that depend on insurance schemes (e.g., self-insured vs. purchased). Other examples are the degree to which substitute workers are available, the ease of realizing job accommodations, as well as the corporate culture regarding management of disability.

Second, future studies should concentrate on improving basic research designs. While advanced designs are appearing more frequently, there is a need for prospective, inception studies so that we may learn more about the nature of the risk factors being studied. Longitudinal studies, as described more below, may benefit from a broad range of sound measures and several repeated measures over time so that they capture the dynamic nature of the problem.

A third concern is the population selected for study. In our view, the sample criteria are extremely important because their characteristics restrict the conclusions that may be drawn. A basic requirement for future research is a clear definition and description of the sample and the criteria for selection. A second basic requirement is studies that employ samples that are representative. To advance the field, and to answer many pertinent questions, early enrollment will be necessary. This involves identifying the onset of the problem and recruiting early on, such as within 3 weeks, so that the development of the problem can be studied. For some questions, early enrollment may not be necessary, but the sample must surely be appropriate for the hypothesis or conceptual idea being investigated. Because work disability has many faces, studying various stages of disability is important. For example, studying the development of problems before work disability occurs is as attractive as studying the return-to-work process. However, new knowledge may also be obtained by studying those out of work due to recurrences as well as those who work despite a back pain problem.

Fourth, assessment should define constructs related to the theoretical base being employed and utilize multifactorial instruments with sound psychometric properties. This is a real challenge as distinct measures are not always available. Moreover, the idea of including many variables and yet measuring them with sound psychometric instruments is quite taxing because the more variables the longer the assessment procedure, and the use of psychometrically sound instruments sometimes results in long questionnaires or methods.

Consequently, there is a need for new, efficient and psychometrically tested assessment methods reflecting current models.

Fifth, data analyses may profit from using multivariate techniques, but with conservative interpretation. Since the issues are multifactorial, data analyses may become clearer with the use of multivariate techniques. Yet, these do not replace clear thinking in model building or appropriate research designs; instead they complement these.

Sixth, follow-up over a relatively long period of time with clear outcome measures and an eye for high response rates is crucial for evaluating the strength and quality of the predictor. In order to capture the dynamic developments that disability and return to work entail, future research would benefit from *repeated* measures over considerable time periods. Rather than view the problem as static, this would provide crucial data on the processes involved and help reveal the nature of the mechanisms. It would also capture the recurrent nature of back pain. For example, some variables may only be relevant at certain time points, while others are important only in certain circumstances. Moreover, some variables, such as stress, may actually show greatest impact when there is an increase or decrease. Identifying such changes requires repeated measures.

Yet another issue related to improving our knowledge is collaboration with key stakeholders. Clearly, to maximize the transfer of knowledge, close contacts are needed. From a research point of view, this offers unique insight into the problem and an opportunity to obtain valuable data. In fact, any screening procedure will need to be periodically "calibrated" and this might best be done through an effort to assist stakeholders in developing sound screening systems.

CONCLUSION

Encouraging progress has been made in the prognosis of work disability. This has resulted in a few interesting attempts to identify those at risk and even to provide tailored interventions based on those risk factors. Much, however, is left to be done. We believe that an interdisciplinary, integrated research paradigm will be of value in moving this area forward. By obtaining better knowledge, we will also be in a better position to transfer knowledge to key stakeholders. This in turn will assist in promoting sound practices that prevent disability and promote return-to-work.

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