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**Validation and Evaluation of a Disability Measure for Upper Extremity
Musculoskeletal Disorder Screening in the Workplace and Prognostic Factors of
Long-term Disability**

Bert D. Stover

A dissertation submitted in partial fulfillment of the requirements for the degree of

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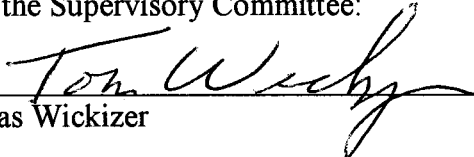
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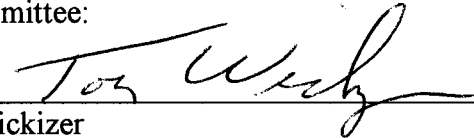
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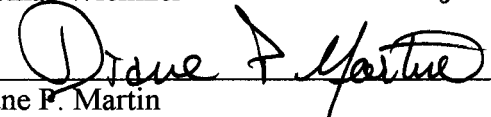


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Abstract

Validation and Evaluation of a Disability Measure for Upper Extremity
Musculoskeletal Disorder Screening in the Workplace and Prognostic Factors of
Long-term Disability

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Ten percent of the American working population is disabled due to workplace injury or illness. This dissertation addresses prevention of upper extremity musculoskeletal disorders and the predictors of long-term disability. Early detection of musculoskeletal disorders is key to successful treatment and to minimize incidence and severity. Disability measures are associated with work status; however, little evaluation has been done in working populations. This study assessed the validity of the QuickDASH disability instrument in a cross-sectional study of 599 full-time workers with upper extremity musculoskeletal symptoms in the previous week. The accuracy of the baseline QuickDASH to identify workers with or likely to develop upper extremity MSD problems at baseline, 4-months, and 1-year. Workers with upper extremity musculoskeletal diagnosis had higher ($p < 0.001$) QuickDASH scores (disability) than those without. A trend of increasing QuickDASH scores with increasing symptom severity category ($p < 0.001$) was observed. There was little correlation between the QuickDASH score and SF-12 physical component score, implying that the two instruments measure different phenomenon. The QuickDASH demonstrated good

internal consistency, and accuracy at baseline for musculoskeletal disorder diagnosis, and symptom severity. Receiver operator characteristic curves, sensitivity, specificity, negative and positive predictive values are provided. Study findings support the validity of the QuickDASH to assess upper extremity musculoskeletal disability in working populations. In addition, predictive factors in a workers' compensation system for guiding preventive interventions to high-risk claims were identified. Claims were followed for 6 years in a retrospective cohort study. There was considerable agreement between logistic, quantile regression, and Cox proportional hazards models. The strongest predictors of long-term disability were hospitalized within 28 days of injury, age, interval between injury and treatment, construction industry, logging occupation, gender, and upper extremity non-traumatic musculoskeletal disorders. Early detection of musculoskeletal disorders in the workplace if followed by appropriate preventive interventions like hazard reduction, modified work, recovery time, task rotation or other measures can serve as tools for primary prevention. Secondary prevention efforts including return to work programs, medical management, detailed communication between employees, employers, medical care providers, and insurance agents can be successful in shortening disability time.

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Dedication

To my father who always provided unwavering support and clear values.

Chapter 1: Introduction

Work related disability is a major problem in society. Improved methods to identify workers early in the disease process are needed to reduce the development of short-term and chronic disability. This research addresses disability reduction through primary and secondary prevention in three studies. The identification of jobs and workers with increased risk for musculoskeletal disorders (MSD) may provide an opportunity for primary prevention through intervention before the condition becomes disabling. The first study, *Validation of the QuickDASH Upper Extremity Disability Measure in the Workplace*, considers the validity of a newly developed functional status instrument to identify disability in the workplace. Several existing questionnaires may be useful for assessment of disability in the workplace but little research has been published demonstrating their validity. The detection of musculoskeletal disorders in the workplace using the QuickDASH is addressed in the second study *Accuracy of a Disability Instrument to Identify Symptomatic Workers Likely to Develop Upper Extremity Musculoskeletal Disorders*. These first two studies contribute to the evaluation of a disability instrument to identify musculoskeletal disorders useful for primary prevention.

Once workers are injured it is essential to identify those at increased risk of long-term disability. Identification of the strongest predictors routinely collected in the Washington State workers' compensation system is the subject of the third study, *Prognostic Factors Of Long-term Disability In A Worker's Compensation System*. The cases that result in disability longer than one year account for most of the disability cost.

Available resources for secondary prevention can be focused on those cases that are most likely to lead to a reduction of long-term disability.

Burden

Musculoskeletal disorders contribute heavily to work-related disability. Musculoskeletal disorders are the most common workplace injury. In 2000 there were 577,800 new work-related musculoskeletal disorders in the American working population, accounting for one in three accepted workers' compensation claims which involved time away from work.¹ MSDs have long disability periods with a median of 25 lost workdays compared to an overall median of 5 days for other illnesses and injuries.² The distribution of lost work days is skewed with average lost workdays of 84 and 87 have been reported for work related MSDs.^{3,4}

Direct costs to workers' compensation insurers for medical treatment costs, insurance system administration, and disability payments in 1995 was \$15 to \$20 billion dollars for workplace musculoskeletal injuries and an additional \$45 to \$60 billion dollars in indirect costs.⁵ These indirect costs include hiring and training replacement workers, loss of production, decline in employee morale, and other expenses. Estimates of cost are conservative because underreporting of workplace injuries is common.⁶ The scope of underreporting is such that less than half of work related MSDs are reported. A comparison of two data sources using capture-recapture methods to estimate the total number of new work related arm and hand disorders in Connecticut during 1995 found that only 5.4% of cumulative trauma cases were reported to workers compensation.⁷

Upper extremity musculoskeletal disorders involve tendons, muscles, ligaments, nerves, and the intervertebral disks of the neck. These disorders have also been referred to as repetitive strain injuries and cumulative trauma disorders. The disorders result in long disability and loss of capacity to function effectively in society. Stock identifies 12 domains which these upper extremity disorders affect: work, family, self-care, transportation, sexual activity, sleep, social activities, recreation, mood, self-esteem, financial, and iatrogenic effects of assessment and treatment.⁸ In many cases these domains are affected for years.⁵ The burden of injury does not end when the person returns to work. Keogh found that among workers' compensation claimants with upper extremity MSD, 53% continued to have persistent symptoms, one to four years post claim, which interfered with work, sleep, and recreation.⁹

There has been a general trend of stable or increasing incidence of musculoskeletal disorders over the past decade, while overall claims have decreased. Although both total injuries and illnesses with lost workdays have decreased since 1992, MSDs account for more than one third of the total lost workday claims (Figure 1.1).¹ In Washington State, overall workers' compensation claims decreased by 4.9% per year while two musculoskeletal disorders, epicondylites and rotator cuff syndrome, increased by 1.5% and 0.5% respectively. Musculoskeletal disorders comprised 47% of accepted claims during 1991 through 1999 including slips, trips and falls.¹⁰

Conceptual Models

Several models link causal factors of musculoskeletal disorders to disability outcomes. These include the balance theory,¹¹ a conceptual model for work-related neck and upper-limb musculoskeletal disorders,¹² a conceptual model for causal factors in work related musculoskeletal disorders,¹³ the disablement process,¹⁴ and the psychosocial model of job content.^{15,16} A model presented by the National Research Council combines several of these and provides specific evidence from the literature supporting it.⁵ Their model shows that the onset and extent of musculoskeletal injury are a result of intensity and duration of physical exposures modified by characteristics of the individual, and the environment. For a given amount of exposure and physiological impairment, there is variability of symptoms and disability across individuals. Onset may occur rapidly over a few hours or, more commonly, gradually over several days or months.¹⁷

One model helps to clarify the importance of adequate recovery time to avoid MSD injury. It proposes that workers may adapt to exposures if sufficient time between exposures is allowed for repair processes in a cascading fashion (Figure 1.2).¹² The physiological and biological response to exposure may lead either to cumulative injury and disability or to increased capacity. With each successive exposure, the response may produce increased or decreased ability of the tissue to cope with the next exposure. Early medical management and the removal of causative factors can minimize the incidence and severity of MSDs.¹⁸ Removal from work for at least two weeks is recommended.¹⁹

Detection of Musculoskeletal Disorders

Associations between risk factors and long-term disability should be developed to support efforts to reduce disability when accurate clinically based predictive tests are not available. Early detection of upper extremity musculoskeletal problems is key to successful treatment and the limitation of disability.¹⁹ However, diagnosis of MSDs is difficult^{20,21,22} and clinical treatment has limited effectiveness, making surveillance and prevention critical.^{6,12,23-25} Criteria for diagnosis are often ambiguous for MSDs without clear pathological processes or physiological mechanisms.^{5,18} Early detection of disorders is often difficult because of insensitive clinical methods and crude resolution in diagnostic tests.²⁰ In a review of clinical diagnostic methods for MSDs of the upper extremity, there was little evidence demonstrating test reliability.²¹ For many MSDs there is no objective way to make a diagnosis or measure severity.²² Back pain conditions are similar in that 85% of cases do not have a specific diagnosis. More often than not symptomatic MSD injuries are not accompanied by x-rays or other positive imaging findings. However, 70% of workers with moderate or severe symptoms, as reported on the National Institute of Occupational Safety and Health (NIOSH) musculoskeletal questionnaire, had at least one clinical sign indicative of MSDs.²⁶ Prognostic factors can play an important role in treatment development and the reduction of disability even though clinical understanding is not very complete for some disorders.

Researchers and federal agencies have cited the need to improve the detection and evaluation of work related MSDs. The NIOSH research agenda proposes work in

developing the definitions of stages of the MSD disease process including discomfort, pain, injury, disability, and recovery.²⁷ The National Research Council recommends research for early detection and prevention of work related MSDs, and improved outcome measures for epidemiologic and intervention studies.⁵ Some tools exist but need to be validated in working populations to assess their accuracy and improve interpretation.²⁸ Few studies have assessed screening instruments for upper extremity MSDs in working populations. The use of muscle force and endurance tests have not been predictive of the development of MSDs. Although some studies address pre-employment and pre-placement exams, using physical measurement, range of motion, strength, and other methods, tests with good positive predictive value for MSDs have not been reported.¹⁷

The gradual onset of MSDs combined with the high frequency of muscle fatigue, stiffness, and soreness in many occupations lead workers to expect symptoms as a normal and typical consequence of work. Without workplace surveillance programs in place, most MSD problems are not reported. The self-report of MSD problems may not occur in the early stages of onset due to the frequent occurrence of symptoms, economic, cultural, workplace, and psychosocial factors that discourage reporting. Estimates indicate that less than 50% of MSDs are reported to supervisors. Symptoms are indicators of musculoskeletal problems that reflect the workers perception but imply an underlying pathology. Pain and discomfort symptoms resulting from musculoskeletal injury are useful in detecting incipient problems.¹⁷ Common symptoms for upper extremity MSDs include pain, weakness, numbness, tingling, and stiffness. Once such

problems last for a week, occur three or more times, or result in swelling or numbness for more than 24 hours follow-up measures are appropriate.

Functional Status

Workers often report the effect of musculoskeletal problems on their ability to perform tasks like buttoning a shirt or specific work tasks. This ability can be quantified by functional status measurements. Functional status measures better discriminate severity and predict subsequent disability better than physical examination or laboratory measures.^{29, 20} Furthermore, functional status measures have been found to be reliable, valid, and sensitive to change in work related musculoskeletal disorders in the clinical setting.^{20, 8} However, there is little research examining the utility of functional status instruments for accurately classifying the working population as normal or abnormal MSD status.

Many factors besides tissue damage that contribute to work disability and variations in functioning are not fully explained by symptoms, or biological, and physiological variables. One model suggests that disability and health status can be viewed as a continuum of increasingly complex combinations of biological and psychological factors.¹³ As measures move from the level of cell to individual to interaction with society, concepts become more complex and integrate more inputs. Functional status is a combination of many factors, some not represented in symptom status, such as personality and motivation. Disability instruments may be more accurate in assessing a person's ability to participate in important life roles, including work.

One approach for early detection of MSDs is the use of functional status instruments for workplace screening. Screening tests should identify the pre-clinical phase before the condition would normally lead to medical attention.³⁰ Surveillance screening should detect injury early, before workers would normally feel compelled to report it.^{17,31} Although variable, MSDs generally have a sufficiently long pre-clinical phase to support the use of screening. A screening test with high sensitivity for detection of MSDs, prior to clinical case definition, can provide an opportunity for preventive intervention.¹²

The aim of chapters 2 and 3 is to assess the validity and accuracy of a new disability instrument, the QuickDASH, for upper extremity MSDs and evaluate its use in working populations. This 11-item upper extremity functional status instrument was derived from a longer 30-item version of the Disabilities of the Arm, Shoulder, and Hand (DASH). These instruments identify those with and without upper extremity MSDs (discriminative), and assess change over time (evaluative). Score range between 0, normal, and 100, severely disabled. The DASH has been validated in assessing MSD incidence and treatment and in epidemiologic studies on various worker populations.^{32,33,34} For example, a gradient in DASH scores was found across levels of severity of impairment.^{35,36} However, the validity of the 11-item QuickDASH has yet to be established. The reliability of the QuickDASH has been established in a study by the developers who found excellent internal consistency ($\alpha = 0.94$) and good responsiveness.³³

Methods Overview

Data were collected between January 2002 and July 2003 from 13 workplaces in Western Washington State from 559 full time workers with some upper extremity musculoskeletal symptoms in the previous week. I assessed the validity and accuracy of the QuickDASH by weighing its score against several outcome measures including upper extremity MSD diagnosis, symptom severity, lost workdays, job change, light or restricted work, obtaining medical care, and SF-12 physical and mental component scores. This research evaluated the QuickDASH by analyzing sensitivity, specificity, negative and positive predictive values, and receiver operator characteristic curves. Internal consistency was assessed with the Cronbach's alpha that provides a measure of the interrelation among items in the QuickDASH.

To assess convergent construct validity, I anticipated a moderate correlation between the SF-12 physical component score and the QuickDASH score. I likewise expected a low correlation between the QuickDASH score and the SF-12 mental component score to investigate the divergent construct validity. I expected that QuickDASH scores for those with a diagnosis of upper extremity MSD would be higher than those without as an indication of known groups construct validity.

Prognostic Factors of Long-term Disability

In chapter 4 I identify factors in a state worker's compensation system that can be measured early and that may predictive of long-term disability. I use Cox and logistic regression in this retrospective cohort study to identify the strongest predictors of long-term disability to provide information useful in targeting resources to high-risk

claims cases. The focus is on injuries and illnesses that result in the greatest time loss and disability burden. The study uses workers' compensation claims data collected by the Washington State Department of Labor and Industries the, agency that administers workers' compensation, to identify the predictors of long-term disability.

This is important because a small percentage of disability claims results in a large percentage of claims costs. Workplace injuries accounted for costs of \$129 billion dollars in 1992 including 2.7 million disabling work injuries in the United States. Current understanding of the factors associated with long-term disability is limited. Additionally, prognostic factors of long-term disability are not consistent across studies. Furthermore, predictors of long-term disability have changed over time with changes in the frequency and type of work. There is a recognized need within the field of occupational medicine for better information regarding the predictors of long-term disability. Return-to-work programs have been successful in getting injured workers back to work,³⁷ but could benefit from updated knowledge about predictors to improve targeting and effectiveness.

The coordination of efforts among stakeholders, including employee, employer, insurance agent, and medical care provider, can reduce long-term disability. The influence of coordinated efforts in return to work, case management, medical services, availability of transitional work, clear communication, and goals that seem appropriate to all stakeholders, should be considered. A progression to chronic disability around 3 months is evident in both the natural history of MSDs and return to work research. MSDs involving the back and upper extremity make up the majority of worker'

compensation claims which involve time away from work. Due to the progression of MSDs from short duration pain, soreness, and numbness to chronic disability, it is crucial to address those factors that influence healing within the first 3 months of the disorder. Advanced cases of MSDs require 6 to 12 weeks for healing. The provision of time away from causative exposures through transitional work, modified work, or time off should be anticipated to avoid re-injury at work. Predictors of long-term disability can be used to guide policy decisions concerning health and safety, human resources, and return-to-work programs that will limit disability.

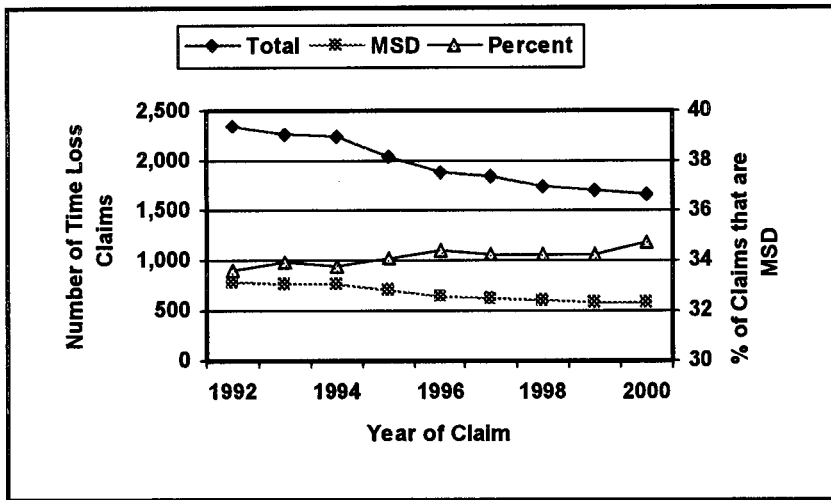


Figure 1.1. Total claims and work-related MSD claims involving time away from work (primary axis) and percentage of total claims that are MSDs (secondary axis)

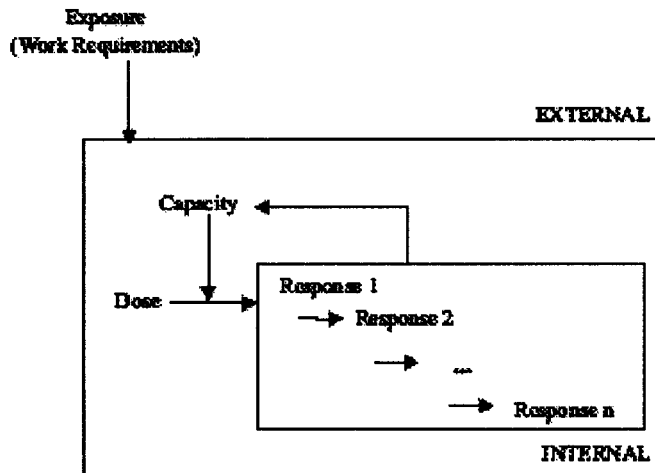


Figure 1.2. Model of pathogenesis of upper extremity musculoskeletal injury¹²

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Chapter 2: Validation of an Upper Extremity Disability Measure in the Workplace

Introduction

Musculoskeletal disorders (MSDs) are the most common workplace injuries today. In 2000 there were 577,800 new work-related musculoskeletal disorders in the American working population, accounting for one in three accepted workers' compensation claims that involved time away from work.¹ The National Ambulatory Medical Care Survey of 1989 reported an estimated 16 million outpatient medical visits for neck, wrist, and hand pain. Additionally, there were 20 million visits for low back pain, making MSDs the second most common condition, after respiratory conditions, for seeking health care.² However, accurate diagnosis of MSDs is difficult^{3,4,5} and clinical treatment has limited effectiveness, making surveillance and prevention critical.^{6,7} Early detection of upper extremity musculoskeletal problems is key to successful treatment and to minimize the incidence and severity of such disorders.⁸⁻¹¹ Accordingly, researchers and federal agencies have called for improved detection and evaluation of work-related MSDs.^{2,12,13}

Symptom questionnaires have proven valid and reliable in the workplace for identifying workers with MSDs. They are used in screening programs to identify workers for more intensive follow-up evaluation by physical exam, detailed work history, and other means.^{14,15} Symptoms are workers' perceptions or feelings of pain, tingling, and numbness. Worker-reported musculoskeletal symptoms were found to predict absence from work due to MSD sickness in a two-year prospective study among metal workers.¹⁶ The Nordic Musculoskeletal Questionnaire (NMQ), a self-

administered symptom survey, was found to be valid and reliable in several studies of workers.^{14,17,18} The hand and wrist component of the NMQ was also found to be valid in the workplace.¹⁹ It was valid and responsive to change for patients treated for carpal tunnel syndrome,²⁰ independent of workers' compensation status.²¹

Disability measures may be effective in detecting the presence and quantifying the effects of musculoskeletal disorders. There is a theoretical basis for suggesting that disability may be appropriate for detecting MSDs. In the present study, functional status refers to individual characteristics involving impairment and meeting a clinical case definition that reflect an individual's ability to execute specific tasks, like walking or lifting objects independent of situational requirements.²² In addition to the worker's perceptions of symptoms, functional status includes the effects of the physical environment and cognitive adaptation. Importantly, functional status includes factors not represented in symptom status, like personality, motivation, and social and economic supports.²³ Disability is a relational concept, demonstrated by a gap between capacity and environmental demand. Verbrugge defines disability as an individual's difficulty in performing activities of daily life, socializing with friends, personal care, or performing a job.²² This definition is central to the construction of the disability instrument used in the present study. For example, a person with carpal tunnel syndrome may have a limitation in function and not be able to button a shirt. However, they may still be able to dress with the aid of special fasteners, and thus are not disabled. The disability instrument used in the present study measures functional status

at the level of disability; specifically, where functional status influences the person's interaction with the environment.

Research suggests disability instruments are appropriate for detecting MSDs. Measures of disability may detect problems earlier, and relate them more clearly to workers' experience of MSDs, than clinical measures like grip strength.³ Additionally, these measures have a strong correlation with work status, suggesting they reflect important factors in a person's ability to work.²⁴ Disability instruments are more sensitive than diagnosis in determining an individual's capacity to participate in important life roles, including work and family.²⁵ Functional and health status measures are more reproducible²⁶ and can better discriminate levels of severity and predict subsequent disability than can physical examination or laboratory measures.^{3,27,24} Baseline functional status of the hands is a significant predictor of work absence at 6, 18, and 30 months, and should be a primary target for intervention.²⁸ In another study, consecutive MSD cases seen by a physician (N=103) in occupational rehabilitation offices in New Zealand during 1994 through 1996 were analyzed to determine predictors of current work hours. Compared with clinical measures and symptoms, worker-reported disability was a better predictor of the number of hours worked following work-related upper extremity MSD.²⁹ However, the psychometric properties of screening tools for detection of MSDs are only beginning to be evaluated in working populations.³⁰ As described more fully below, the aim of this study is to assess the validity of a new disability measure for upper extremity MSDs, known as the QuickDASH.

The QuickDASH is a recently released upper extremity disability instrument designed to quantify the severity of musculoskeletal disorders. It was developed by the Institute of Work and Health, and the American Academy of Orthopedic Surgeons. The QuickDASH measures components of functional status, like sleeping, recreation, and work, at the level of disability as described by Verbrugge's²² disablement process.³¹ The 11-item QuickDASH is a shorter version of the 30-item DASH intended, in part, to reduce the administrative burden of using the instrument. Validation studies of the QuickDASH have not been published. However, initial testing by the developers indicates that, among groups of patients, the questionnaire has good internal consistency (Cronbach's alpha, 0.94) and excellent test-retest reliability (interclass correlation coefficient, 0.94). Construct validity was demonstrated by strong correlations with visual analog scales of overall problem $r=0.70$, and ability to function $r=0.80$. (Institute of Work and Health. QuickDASH Outcome Measure Brochure. www.dash.iwh.on.ca)

Upper Extremity Disability Measure

The 11-item QuickDASH was derived from a longer 30-item instrument, the Disabilities of the Arm, Shoulder and Hand (DASH).³³ These instruments were developed to quantify physical disability and symptoms for the entire upper extremity region for use in workplace and clinical settings, and for acute or chronic upper extremity MSD disorders. The DASH has been shown to have good internal consistency and validity among MSD patients.^{31,39} Items included in the DASH were based on a literature search of instruments for upper extremity MSDs. Items were

selected for inclusion in the DASH based upon a theoretical framework that included 11 key domains.

Three methods were used to select items for the QuickDASH; a conceptual model, equidiscriminative item-total correlation, and item response theory. This resulted in three distinct instruments. The conceptual model instrument was chosen as the final QuickDASH instrument after comparing its performance with the two other instruments. First, the conceptual method used three scales to evaluate each item; expert judgment of item importance to upper extremity MSD evaluation, the difficulty respondents had in answering the item, and item correlation with the full DASH score. The highest ranking item for each of the 11 domains was selected for inclusion. Second, equidiscriminative item-total correlation was used to select items having the highest correlation with the overall score. The QuickDASH was developed to provide a measure that has low administrative burden and is quick to score and interpret. QuickDASH items include difficulty with everyday activities, work, household chores, washing back, recreational and social activities, sleeping, pain severity, and tingling, among others. More information about the QuickDASH and its development is available at www.iwh.on.ca.

The 11-items have responses of 1 to 5. The QuickDASH is scored by summing the item responses, dividing this sum by the number of responses, subtracting 1, and multiplying by 25. The score ranges between 0-no disability, to 100-severely disabled.

In addition to the 11-item survey, the QuickDASH includes a 4-item Work Module questionnaire that is used for work that requires higher performance than daily

activities like dressing.³¹ The Work Module is scored separately from the QuickDASH, although it has the same 0 to 100 score range, with 0 indicating no disability. It contains questions addressing the difficulty the worker has in performing work tasks, including interference due to pain, amount, and quality of work. One question is, “Do you have difficulty using your usual technique at work?” Analysis of responses to the Work Module provides information concerning the worker’s perception of the extent upper extremity MSD problems interfere with work. There are no peer-reviewed publications concerning the validity or cross-sectional precision of the work module.

The aim of this study is to assess the construct validity of the QuickDASH by comparing its score with clinical diagnosis, symptom severity, and the SF-12 Health Survey in a sample of 559 workers who are participating in an ongoing longitudinal study of upper extremity MSDs, described more fully below.

Methods

Study Design

I assessed the validity of the QuickDASH disability instrument in a cross-sectional study by comparing its scores with clinical diagnosis, symptom severity, and SF-12 physical and mental component scores. Workers with at least one clinical diagnosis were expected to have significantly greater disability, and thus higher QuickDASH scores, than workers without a diagnosis. Similarly, workers with more severe symptoms were expected to have higher QuickDASH scores compared to workers with less severe symptoms. A moderate correlation with the SF-12 physical component score and a low correlation with the mental component score were expected.

I also assessed the internal consistency of the QuickDASH with inter-item correlation, as measured by Cronbach's alpha. Internal consistency is the magnitude of interrelation among a set of items in a scale. For the present study, Cronbach's alpha indicates the degree that all items in the QuickDASH measure the concept of disability.

Several types of validity are important to instrument validation. Content validity concerns the clarity, comprehensiveness, and redundancy of items in an instrument.³² The developers of the QuickDASH have previously addressed the content validity of the instrument.³³ Ideally, a new measure would be validated by assessing its performance in comparison with an established instrument for measuring the disease, which is referred to as criterion validity. Since there is no gold standard for measuring disability of the upper extremity, I assessed the instrument's construct validity by comparing its score with clinical diagnosis, symptom severity, and SF-12 measures.

Construct validity examines the relationships between the QuickDASH and other measurements, or constructs, of disability. Hypotheses are developed regarding the expected relationships, and responses are evaluated to determine if these are found.^{31,34,35} Construct validity is related to the population or specific application of the test, and the spectrum of illness severity in that population. Therefore, construct validity should be evaluated in a population similar to the population in which the instrument is intended to be used.³⁶ I examined the validity of the QuickDASH in a working population with a wide range of upper extremity MSD severity to investigate its validity for use as a screening instrument. Hypotheses concerning construct validity may predict convergent construct validity where the measures being compared are moderately or

highly correlated. I anticipated a moderate correlation between the SF-12 physical component score and the QuickDASH score as an indication of convergent construct validity. The hypotheses may also indicate divergent construct validity, where different constructs are not expected to converge or correlate well.³⁶ I compared the QuickDASH score with the SF-12 mental component score to investigate the divergent construct validity. A low correlation between DASH scores and the SF-36 mental component scores have previously been found, Spearman $r_s=0.38$, providing some evidence for divergent construct validity.³⁷ However, the DASH evaluation was conducted in a population of patients rather than active workers as in the present study. Workers with emotional distress due to reasons other than MSDs may evaluate their functional status more pessimistically than workers without emotional distress. However, disability and lowered functional status may cause higher levels of emotion distress, and lower mental component scores. It is not possible to comment on the directional influence of emotional distress in this crosssectional study. I anticipated a low correlation between the QuickDASH score and the SF-12 mental component score as an indication of divergent construct validity. Construct validity can also be demonstrated with the comparison scores across groups with known characteristics. I expected QuickDASH scores for workers with a diagnosis of upper extremity MSD to be higher than for workers without such a diagnosis.

Data Source and Study Population

This study analyzed data from 13 workplaces in Western Washington in the manufacturing or health service industries. These workplaces agreed to participate in a larger, ongoing prospective study of upper extremity MSDs being conducted by the Safety and Health Assessment and Research for Prevention (SHARP) program at the Washington State Department of Labor and Industries. All data for the current study were collected at the baseline interview of the SHARP study. Worksites participating in the SHARP study include a sawmill, window manufacturer, automotive parts manufacturer, electronics manufacturer, hospital laundry service, and a research facility, among others. Participant worksites were selected from among a larger set of worksites that volunteered for the SHARP study. To be included in the SHARP study, worksites had to have a minimum of 200 full-time workers, and jobs in industries with exposures related to development of MSDs.

To ensure that workers included in the study had a wide range of workplace exposures, each candidate job was initially categorized by an ergonomist during a workplace tour. Job exposure was categorized by three levels of hand repetition and two levels of hand force, resulting in six exposure cells, from low repetition-low force to high repetition-high force, according to the Hand Activity Level instrument.³⁸ The subjects included both new and experienced workers. Symptom questionnaires, physical examinations, nerve conduction studies, work histories, work exposures, and other data were collected at the baseline workplace visit after the study had been explained. Data forms for the determination of upper extremity MSD diagnosis, symptom severity, and

QuickDASH were completed by SHARP interviewers. The SF-12 Health Survey was completed by the workers themselves. Trained interviewers from SHARP collected data from workers during regular work hours on paid time between February 2002 and April 2003.

Of the 759 baseline workers in the SHARP study, 559 indicated that they had experienced upper extremity symptoms in the previous week, qualifying them for QuickDASH interview. This validation study was approved by the Washington State Institutional Review Board.

Comparison Measures

I evaluated the construct validity of the QuickDASH by comparing QuickDASH scores with clinical diagnosis, symptom severity, and SF-12 General Health Survey⁴⁰ physical and mental component scores. Symptom severity, clinical measures,²⁴ and SF-12⁴¹ have been used in other studies of MSD disability instrument validation, including the DASH and the Upper Extremity Function Scale.²⁴ Diagnosis of upper extremity musculoskeletal disorders was based on physical examination, health history, nerve conduction studies, self-reported symptoms, and other information following criteria previously described.⁴² Symptom severity was defined as the maximum response among four body parts: neck, shoulder, elbow/forearm, and wrist/hand in the last week (Table 2.2). An example of a symptom severity questions is, “In the past week, how would you rate the symptoms in your neck at its worst?” Responses are, none 0, mild 1, moderate 2, severe pain 3, and very severe 4. Symptom severity was also dichotomized

for some comparisons, with none, mild, or moderate symptoms=0, and severe or very severe symptoms=1.

QuickDASH developers recommend replacing missing values if one of the 11 responses is missing. Accordingly, 35 workers had one missing value replaced with the average of the 10 completed responses. Eighteen workers responded to fewer than 10 items and were excluded from the study.

Analysis

Several different statistical analyses were performed, using two tailed test, including parametric and nonparametric tests, to assess the validity and consistency of the QuickDASH. I assessed the construct validity of the QuickDASH by comparing the disability scores for those with and without clinical diagnosis of upper extremity MSD using a t-test. I expected that workers with at least one clinical diagnosis would have a significantly higher QuickDASH score (more disability) than those without a diagnosis at the $p < 0.01$ level. Similarly, a t-test was used to determine if those with severe symptoms had significantly higher QuickDASH scores than those without at the $p < 0.01$ level. The QuickDASH score distribution was skewed; however, normal distribution of variables for t-tests is not required when sufficiently large samples are available.⁴³ Sufficiently large often means that fewer than 100 observations can give valid results with non-normal data depending on the application. I used a Kruskal-Wallis test to determine if QuickDASH scores, from the five symptom severity levels, were from the same population and expected a non-significant test $p > 0.05$. I used a non-parametric test of trend, STATA nptrend,⁴⁴ to determine if the QuickDASH scores increased with

increasing symptom severity at the $p < 0.01$ level. To support the validation findings for symptom recall in the past week, I also examined the QuickDASH score in relation to symptom recall of one month and one year using the same methods.

I assessed the degree of correlation between the QuickDASH score and the SF-12 physical component scale. Due to the skewed distribution of the QuickDASH scores, the Spearman correlation was used. I expected a moderate correlation with the SF-12 physical component scale because it measures global health status and is not specific to the upper extremity, unlike the QuickDASH. A Spearman correlation of 0.50 with $p < 0.01$ between these measures was anticipated. To assess divergent construct validity, I examined the Spearman correlation between the QuickDASH score and the SF-12 mental component score. I anticipated a lower correlation, less than 0.20, because the QuickDASH was not developed to measure mental function.

The Work Module scores were compared for diagnosis status, symptom severity level, and SF-12 physical and mental component scores. I expected that those with at least one upper extremity MSD diagnosis would have higher scores than those without. Similarly, I anticipated that scores would be lower in association with none, mild, or moderate symptoms. As with the QuickDASH, I expected Spearman correlations of greater than 0.50 between the Work Module and the SF-12 physical component score and correlation of less than 0.20 between the Work Module and the SF-12 mental component score.

I measured internal consistency in terms of the degree of intercorrelation among items in the QuickDASH, as represented by Cronbach's alpha, which ranges in value

from 0 to 1.³⁶ The closer the coefficient is to 1 the greater the consistency of item responses. I expected high inter-item correlation ($\alpha > 0.80$), given the alpha (0.94) found by the developers in the initial testing of the QuickDASH. The initial testing was done among patients with more disability than the active workers in the present study, likely resulting in better agreement among QuickDASH items. All analyses were performed with STATA version 7.⁴⁵

Results

Workers were between 18 and 64 years old with an average age of 40.3 (SD=11.0). Of the 540 who reported weight and height, the mean body mass index was 27.5 (SD=6.0). Prevalence of concurrent health conditions, determined by a medical doctor, and relevant to upper extremity MSD risk, were reported by 191 (34.2%) workers at baseline. Arthritis was reported by 93 (17%) workers, diabetes 20 (4%), gout 5 (1%), thyroid 36 (6%), high blood pressure 88 (16%), and Raynaud's syndrome 4 (1%). Similarly, 184 (33%) workers reported a medical doctor had told them they had or have an upper extremity MSD diagnosis, including a ruptured disk in their neck, carpal tunnel syndrome, thoracic outlet syndrome, hand or wrist tendinitis, epicondylitis, rotator cuff syndrome or trigger finger (Table 2.1).

The QuickDASH score had a mean of 16.7 (SD=16.2), and a median of 11.4 (IQR 4.5-25.0). There was a pronounced floor effect: 59 (10.5%) workers had a score of zero, and another 59 had the next lowest score of 2.3. Since zero represents no disability, values at or near zero indicate evidence of a floor effect. One participant had the high score of 78.5 (Figure 2.1). Among those with positive MSD diagnosis, 126

(61%) had one diagnosis, 60 (29%) had two diagnoses, and 21 (10%) had more than two diagnoses. Workers with an upper extremity MSD diagnosis had significantly higher ($p < .001$, $t = 7.3$) QuickDASH scores (mean = 23, SD = 17) than workers without a diagnosis (mean = 13, SD = 14).

There were 474 (85%) workers with none, mild, or moderate symptoms, (Table 2.2). These workers, on average, had a QuickDash score of 13.2 (SD=13.3). In contrast, 85 (15%) workers with severe or very severe symptoms had an average score of 36.3 (SD=17.4) ($t=14.0$ $p < .001$). I also compared the QuickDASH scores across the five symptom severity categories. Based on the Kruskal-Wallis test, I rejected the null hypothesis that the scores in the symptom severity categories were from the same population, ($\chi^2=235$, $df=4$, $p < 0.001$). Furthermore, a non-parametric test of trend indicated increasing QuickDASH scores with increasing symptom severity category ($z=15.3$, $p < 0.001$) (Figure 2.2). Comparisons of QuickDASH scores based on three month and one year recall of symptoms yielded results of similar magnitude and statistical significance. However, the size of the trend diminishes as the length of symptom severity recall increases. Workers report higher QuickDASH scores for symptoms for one-week recall compared to longer recall periods of four months and one year. As time from symptoms increases, the recall of disability decreases, even though workers are reporting the worst symptom of the entire period.

Of the 559 workers who completed baseline data, 475 (85%) completed all 12 responses to the SF-12. The mean SF-12 physical component score was 48.7 (SD=8.7), with a minimum score of 21.7 and maximum of 67.7. The SF-12 component scores are

constructed so that the mean is 50 and standard deviation is 10 in the general population. Correlation between the QuickDASH score and SF-12 physical component score was $r_s = -0.03$ ($p=0.48$). Furthermore, the physical component score did not differ significantly across levels of symptom severity.

The mean SF-12 mental component score was 49.9 (SD=9.9). There was little correlation between the QuickDASH score and the mental component score of Spearman $r_s=0.06$ ($p=0.21$). Additionally, the mental component scores did not differ statistically across the levels of symptom severity.

The QuickDASH demonstrated good internal consistency, as measured by Cronbach's alpha ($\alpha = 0.87$), indicating that the items relate well to the same underlying concept. Item to test-total correlation ranged from 0.53 to 0.76. The lowest correlation was for rating the severity of tingling in the last week, whereas the highest correlation was for rating the ability to carry a shopping bag or briefcase in the last week.

Work Module scores were substantially skewed, with 285 workers (51%) having a 0 score, thus exhibiting floor effect, with many workers reporting no disability. Six workers, from the 559 that completed the QuickDASH, did not complete the Work Module. Scores ranged from 0 to 100 with a mean of 11.6 (SD=17.0). Two workers had the maximum scale score possible (100), while 96% of the workers scored 50 or lower. Workers with any upper extremity MSD diagnosis on average had significantly higher Work Module scores than those without any MSD diagnosis, 16.2 (SD=19.7) versus 8.9 (SD=14.6), $t = 4.93$ ($p < 0.001$). Workers with severe or very severe symptoms in the last week had significantly higher Work Module scores compared with workers who had

either no symptoms or mild or moderate symptoms, mean 28.2 (SD=23.2) versus 8.7 (SD=13.8), $t= 10.47$ ($p < 0.001$). The Kruskal-Wallis test indicated that scores in the five symptom-severity categories were from different populations ($\chi^2=112$, $p < 0.001$). Furthermore, there was a significant trend of increasing Work Module scores associated with increasing symptom severity ratings, as indicated by a nonparametric test of trend ($z= 11.3$, $p < 0.001$). Neither the physical nor mental SF-12 component scores were correlated with the Work Module scores. The correlation for the physical component score is $r_s=-0.01$ ($p=0.90$), and for the mental component $r_s=0.02$ ($p=0.68$). The internal consistency of the Work Module was excellent, as indicated by a Cronbach's alpha of 0.89. Individual question correlation with the test total work module score ranged from 0.84 to 0.90. The QuickDASH and Work Module scores were significantly correlated with $r_s= 0.61$ ($p < 0.001$).

Discussion

The findings of this study support the validity of the QuickDASH as an instrument to assess upper extremity MSD disability in working populations. The finding of a statistically significant trend of increasing QuickDASH scores with increasing levels of upper extremity symptom severity, along with the finding of significantly higher QuickDASH scores for workers with a diagnosis versus without a diagnosis, supports the construct validity of the QuickDASH. Similar findings were reported for the longer (31-item) DASH for patients with ulnocarpal impingement.³⁷ The patient population used for that study did not include workers. To date, the DASH has not been validated in working populations.

The QuickDASH failed to correlate with the SF-12 physical component score, implying that the two instruments measure different phenomenon. Other researchers have found correlations of 0.74 between the DASH and the SF-12 physical component⁴¹ in surgical patients. However, I expected lower correlations because workers in the present study are healthy enough to work full-time. Further, SF-12 physical component scores did not distinguish between workers with or without a MSD diagnosis $t=0.38$ ($p=0.70$). Consistent with these findings, the SF-12 physical component scores did not differ for workers without symptoms or with mild or moderate symptoms compared to workers with severe or very severe symptoms $t=0.34$ ($p=0.74$). Analyses conducted on the SF-12 mental component scores exhibited this same general pattern of findings.

The low correlations ($r's < .05$) I found between the SF-12 physical and mental component scores and the QuickDASH scores differ from other findings conducted on the (longer) DASH among MSD patients scheduled for surgery ($r's > .55$).⁴¹ My findings also differ from the findings reported for the DASH, which are based upon the SF-36 physical functioning and pain scales ($r's > .55$) among MSD patients.³⁷ These differences may be a consequence of differences in study populations. This study population consisted of workers who were healthy enough to be employed. In contrast, other validation studies of the DASH have been conducted on patient populations and individuals scheduled for surgery. Whereas the average QuickDASH score for workers in the present study was 16.7, corresponding scores from other DASH validation studies conducted on patient populations^{41,46,47} were over 27, and more typically over 33 (higher DASH score represents greater disability). The QuickDASH was developed to

assess disability of the upper extremity and not global health status. The SF-12 and SF-36 health surveys are intended to measure global health status. Findings from one study suggest that SF-36 items are weighted toward lower extremity functioning. That study included workers who had filed a workers' compensation claims and found that workers with upper extremity MSDs appeared to be healthier than subjects with low back pain, as measured by the SF-36 physical function and pain dimensions.⁴⁸

This analysis showed the QuickDASH to have good internal consistency (Cronbach's alpha 0.84), indicating that the 11-items measure the same general concept.

The Work Module and QuickDASH had a moderate correlation of $r_s = 0.62$ and discriminated well between groups based on diagnosis and symptom severity status. Like the QuickDASH, the Work Module did not correlate with the SF-12 physical or mental component scores. The similarity in performance indicates that the instruments are measuring similar phenomena. Workers report less effect from upper extremity MSDs on their work, as addressed in the Work Module, than on household chores and other daily activities, as addressed in the QuickDASH, for all but the most severe symptoms. Workers may be reluctant to admit that problems interfere with their work in order to convince themselves, or employers, that they are ready and willing to continue working. This suggestion is consistent with other findings from a survey of 537 workers' compensation claimants indicating that workers' home and recreational activities are affected more than work activities by upper extremity MSDs.²⁵

The SHARP study, which provided the data for the present analysis, was not designed to assess instrument validation. Consequently, QuickDASH scores were not

collected from workers without some upper extremity musculoskeletal complaint in the last week. There were 200 workers in the SHARP study that provided baseline data but did not provide information for the QuickDASH. These workers were on average younger (37 years vs. 40 years) and had worked less time with their current employer for (5.0 vs. 6.6 years) than those who had symptoms and completed a QuickDASH. Male workers made up 65.5% of this group (n=200) compared to 44% of those who completed a QuickDASH. Upper extremity MSD symptoms were reported by 25 workers in this group and therefore should have been given a QuickDASH but were inadvertently not administered the QuickDASH. Among these 25 workers, 4 reported severe symptoms, 6 moderate symptoms, and 15 mild symptoms. The remaining 175 subjects reported no symptoms in the last week. Evaluation of ceiling and floor effects is limited because 200 of the 759 baseline workers did not provide QuickDASH information due to lack of musculoskeletal problems in the past week. However, the distribution of the QuickDASH scores among those who did have some problem is skewed, with 59 (11%) workers reporting no disability (a zero score) and 59 more workers with the next lowest score of 2.3 (Figure 2.1). This indicates that the QuickDASH does not differentiate well among workers with low levels of disability. However, it does distinguish between those reporting none or mild symptom severity, which may be adequate for workplace screening and surveillance applications. The large number of zero scores shows that the QuickDASH would not be sensitive to improvement among those with low levels of disability. This suggests that nonzero scores should be an indicator that closer scrutiny of persons and jobs is warranted. With

a high QuickDASH score of 79.5 out of 100, the instrument can measure more severe disability than present in this working population.

Symptom measurement is important for the assessment of job tasks and hazard identification. However, disability measurement may be useful for screening large worker populations quickly in order to identify jobs or tasks warranting further evaluation for MSD hazards. The validation of instruments that measure upper extremity disability may lead to improved detection and evaluation of jobs associated with the development of MSDs. Detection could trigger early workplace intervention and reduce the prevalence, cost, and morbidity associated with upper extremity MSDs.

Table 2.1. Characteristics of the study population
(n=559)

Characteristics		No.	%
Age	18-29	111	(20)
	30-39	147	(26)
	40-49	166	(30)
	50-64	135	(24)
Male		246	(44)
Race	White not Hispanic Origin	358	(64)
	Asian or pacific Islander	102	(18)
	Hispanic	56	(10)
	American Indian, Alaskan Native	20	(4)
	Black not Hispanic Origin	17	(3)
	Other, Unknown	6	(1)
BMI kilograms/meters ²	16-23	130	(24)
	>23-26	125	(23)
	>26-30	136	(25)
	>30-50	149	(28)
Current smoker		161	(29)
Years of symptoms *, median (range)		3.74	(0.07-35.39)
Years in job, mean (SD)		6.64	(7.10)
Concurrent condition		191	(34)

Table 2.1. Continued

Characteristics	No.	%
Previous upper extremity MSD diagnosis, No. (%)		
ruptured disk in their neck	7	(1)
carpal tunnel syndrome	51	(9)
thoracic outlet syndrome	3	(0.5)
hand or wrist tendinitis	65	(12)
epicondylitis	35	(6)
wrist fracture	57	(10)
rotator cuff syndrome	30	(5)
trigger finger	8	(1)

* Years of upper extremity MSD symptoms at baseline for the longest duration problem across neck, shoulder, elbow/forearm, and wrist/hand.

Table 2.2. Distribution of upper extremity MSD diagnosis and symptom severity at baseline

Diagnosis or Symptom	No.	%
Upper extremity MSD diagnosis at baseline	207	(37)
Neck	11	(2)
Shoulder	75	(13)
Elbow	63	(11)
Hand or wrist	113	(20)
Symptoms *		
None	85	(15)
Mild	183	(48)
Moderate	205	(37)
Severe	72	(13)
Very severe	13	(2)

* Symptom severity in the past week

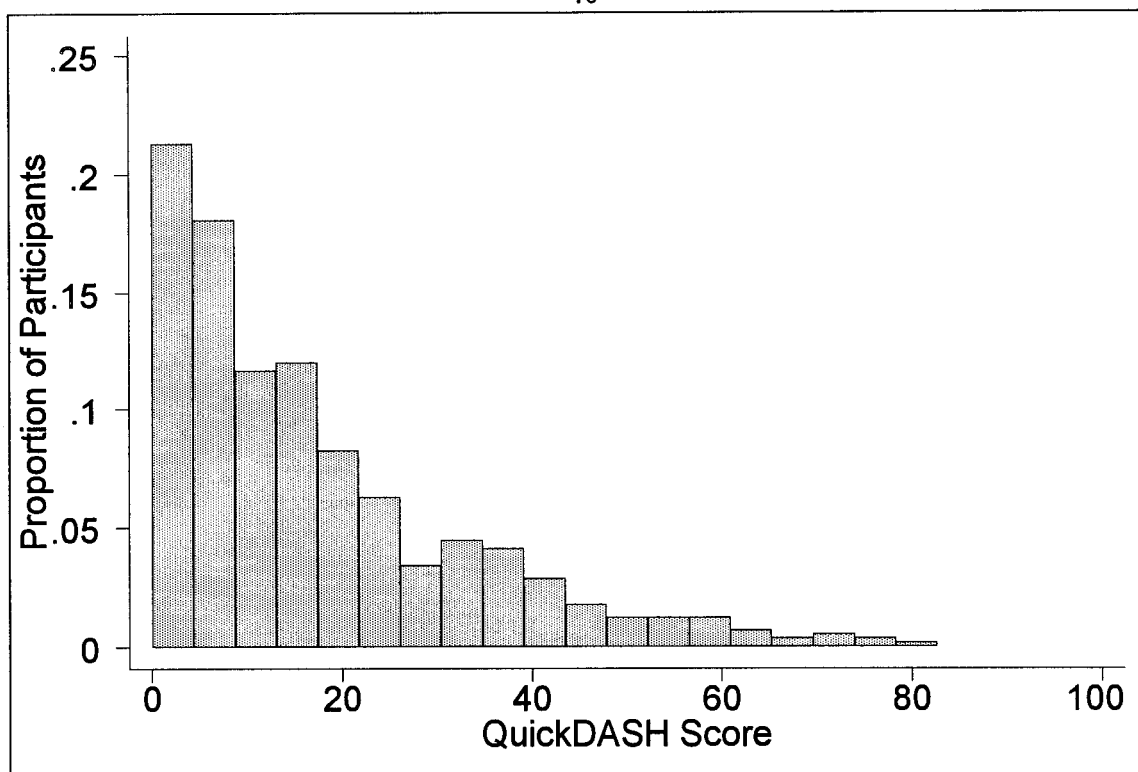


Figure 2.1. Distribution of the QuickDASH score
n=559 mean 16.7 (SD 0.69), median 11.4, IQR 4.5-25.0.

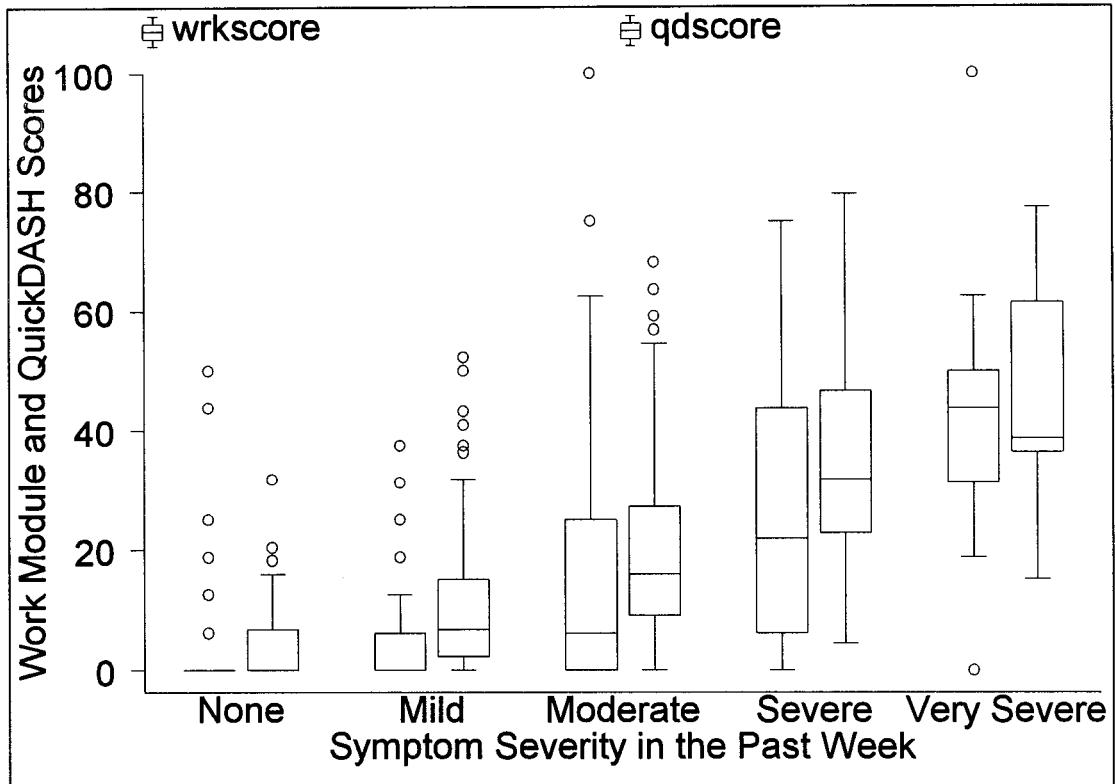


Figure 2.2. Boxplot of QuickDASH and Work Module scores by symptom severity category for one-week recall. The Work Module score is shown on the left in each boxplot pair.

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Chapter 3: Accuracy of a Disability Instrument to Identify Symptomatic Workers Likely to Develop Upper Extremity Musculoskeletal Disorders

Introduction

The loss of workers from the workforce and the economic costs resulting from upper extremity musculoskeletal disorders (MSD) warrant preventive intervention. Early workplace detection can facilitate successful interventions that reduce the incidence and severity of these disorders. A few questionnaires have been developed for this early detection of MSDs in the workplace. However, little research has been published that describes their validity and accuracy. This study evaluates the accuracy of a disability instrument for classifying workers for upper extremity MSDs.

MSD Burden

Work related disability associated with upper extremity musculoskeletal disorders is a major problem for families, employers, and society. Upper extremity MSDs affect many life domains that influence work performance, family responsibilities, self-esteem, sleep, social and recreational activities and others.¹ Upper extremity MSDs have long disability periods. For example, in Washington State the average disability duration was 160 days for workers receiving compensation for carpal tunnel syndrome.² And many workers continue to have ongoing problems after returning to work. For example, 53% of Maryland workers with upper extremity MSDs continued to have persistent symptoms that interfered with work, sleep, and recreation during a four year post-injury period.³ Replacement wages provided by workers' compensation systems are well below workers' foregone wages. One study of the

California workers' compensation system showed that benefits provided only 40% of lost earnings over a 5-year period following injury. Furthermore, injured workers received 40% lower earnings during employed periods in a 5-year post-injury period compared to a control group of workers who had the same earnings for a 5-year pre-injury period.⁴

The economic cost of MSDs to employers is also high. In the United States in 1995 employers paid \$15 to \$20 billion dollars in workers' compensation expenditures for workplace musculoskeletal injuries, and \$45 to \$60 billion dollars more in indirect costs, like hiring and training replacement workers, lost productivity, uncompensated lost wages, lost tax revenue, and social security replacement benefits.⁵ For every 1000 workers in the Washington State workers' compensation system in 1986, 219 days of productivity were lost due to carpal tunnel syndrome alone.⁶ The problem is larger than these numbers reflect because less than half of work-related MSDs are reported.^{7-8,9} Several studies show a much lower percentage (20-25%) of workers report problems to employers or file workers' compensation claims.¹⁰⁻¹²

Detection of MSDs

Researchers and federal agencies have cited the need to improve detection and evaluation of work-related MSDs. The NIOSH research agenda calls for improved definitions of stages of MSD disease process, including disability, discomfort, and pain.¹³ The National Research Council and the Institute of Medicine recommend research for the early detection and prevention of work-related MSDs, and improved outcome measures for epidemiologic and intervention studies.⁵ Early detection can be

facilitated through workplace screening and is effective when included in surveillance programs that make full use of the screening results. Detection of upper extremity musculoskeletal disorders and early intervention have been successful in reducing disability and cost.¹⁴⁻¹⁶ However, there is no gold standard for identifying workers with upper extremity MSDs.¹⁷ Some tools for detection and evaluation of MSDs exist but need to be validated in working populations to assess their accuracy and improve interpretation.^{17 18}

Workplace Surveillance and Screening

One approach to early detection of MSDs is the use of workplace screening instruments as one component in the larger process of workplace surveillance programs. Surveillance is the ongoing systematic collection, analysis, interpretation, and dissemination of health and hazard information in order to identify trends, develop prevention strategies, and evaluate the effectiveness of those strategies.^{13,19} Methods for collection of surveillance data emphasize practicality, uniformity, and rapidity rather than accuracy and completeness.²⁰ Many workers are exposed to hazards associated with MSDs so screening tests need to be easy to administer and interpret to be practical in the workplace. Questionnaires are less expensive, quicker, and easier to use than nerve conduction studies and MSD targeted physical exams. Additionally, workers may be less averse to completing questionnaires than undergoing nerve conduction testing or physical examination. Attention needs to be focused on analysis that identifies large and stable patterns between jobs or departments, and evaluates safety interventions.²¹ Job specific incidence and prevalence rates can be calculated to help identify jobs in which

workers are experiencing disability or discomfort and to establish priorities in addressing these problems.

The use of screening tools in surveillance programs is indicated when jobs, tasks, or processes are initiated. Screening tools are also appropriate when administrative data (lost work, MSD claims) indicate that there is a high rate of disorders or many ergonomic stressors in the workplace. They are also useful for establishing workers baseline status when hired.²² Both health (symptom or functional disability surveys) and musculoskeletal risk factor surveillance (checklists or job analyses) should be conducted before workplace interventions are initiated to provide a baseline for evaluating the intervention performance.²¹

Disability instruments, and other active surveillance tools, are not routinely used in administrative data systems and thus require extra resources. Alternatively, passive surveillance uses existing administrative data, like injury rates, absentee records, or job title, and requires no additional resources. However, active surveillance often obtains injury information earlier than workers would normally report it.²¹ Passive surveillance measures like lost workdays may be insensitive to upper extremity MSD incidence because many workers continue to work despite experiencing symptoms and pain. For example, among Canadian newspaper workers with some musculoskeletal symptoms, 15% experienced work disability while 58% experienced disability in other roles.²³

Disability instruments could be used as an intermediate measure between symptom questionnaires (like the NMQ) and lost workdays or workers' compensation claims. However, a large proportion of workers, 32%, were found to have ongoing

health problems that interfere with work in a national survey.²⁴ This is an important consideration in using disability measures in surveillance programs and necessitates baseline measurements before meaningful disability rates can be determined for a particular workplace. The functional disability instrument used in the present study specifically seeks information related to upper extremity problems, thus avoiding positive screening tests related to other types of disability. If the use of disability instruments becomes common, and normative scores are known, initial measurements may be of comparative value.

Screening instruments are not intended to make clinical diagnoses but may be useful in surveillance for detecting new cases at an early stage. Early detection could provide surveillance programs with a method for triggering follow-up examination, medical management, and task or job evaluation.²¹ If functional status instrument scores (or other components of active surveillance) are associated with the level of productivity, a business case could be made to support their use.

Screening is useful to classify those who have or are likely to develop MSDs. There are many reasons for underreporting MSDs. One is that many workers believe early symptoms are normal and acceptable. The gradual onset, common symptoms, and usual course of recovery without treatment, contribute to the general lack of concern for early symptoms. Screening tests need to identify the pre-clinical phase before the condition would normally lead to medical attention.²⁵ Like clinical screening, surveillance screening aims to detect injury early, before workers would normally feel

compelled to report it.^{21,26} Although variable, MSDs generally have a sufficiently long pre-clinical phase to justify the use of screening instruments.

A screening test with high sensitivity for detection, prior to development of explicit patterns of symptom development and clinical case definition, can provide a window for prevention.^{27,28} The high sensitivity of the screening test may be balanced by more specific testing to determine the severity of the condition. The accuracy of a screening tool depends upon its sensitivity and specificity. However, there is no accepted standard for these traits. Screening tests need to minimize the false positive rate due to normal variation and measurement error to avoid unnecessary, expensive, or excessive follow-up services. If a screening instrument is not sensitive, it will fail to identify workers likely to develop musculoskeletal disorders. False positive tests will result in healthy workers receiving follow-up health related interviews or brief surveillance physical examinations at a cost much below the cost of a MSD disability claim. Therefore, sensitivity of 70% and specificity of 50% were used as the target accuracy criteria in the present study. The sensitivity and specificity criteria used to evaluate the usefulness of a test is determined entirely by the context in which it is used.^{33,34} For other applications of the QuickDASH, different threshold scores may be desired. For example, in epidemiological studies a score that results in the highest number of workers correctly classified would be desired.

Postural discomfort measures, like the Body Part Discomfort Scale,²⁹ may detect exposures and trigger interventions before workers become injured. They are commonly used for assessing the performance of workplace ergonomic interventions. These

instrument scores have been shown to be associated with biomechanical torque, the time a subject could hold a posture, and postural loading at the joints.³⁰ The relationship between postural discomfort measures and development of upper extremity MSDs has not been investigated. However, reporting of MSD symptoms has been found to be associated with discomfort scores.³¹ Postural discomfort measurements may be useful in identifying jobs, tasks, or workers that have sufficient exposures and increased risk of developing upper extremity MSDs. Body part discomfort scales provide a complementary method for primary prevention efforts focused on MSDs.

Simple symptom surveys, body part specific instruments, or functional disability instruments require few resources to collect and analyze. More complete symptom questionnaires or Nordic Musculoskeletal Questionnaires, while still relatively easy to use, can provide more specific information about the problem.³² However, questionnaire accuracy depends on the workers responses. Additionally, it is not known if information obtained from questionnaires is biased with repeated use in the same population.¹⁹

Checklists for identifying musculoskeletal hazards in the workplace are useful for identifying problems with jobs, tasks, or equipment that may be the cause of musculoskeletal problems. Risks may be identified before workers recognize problematic symptoms and interventions initiated before workers are injured. If resources are very limited, risk factor identification should have priority in surveillance programs.²¹ These instruments are completed by health professionals thus they do not rely on the accuracy of worker responses. These instruments can identify situations

where risk factors like force, repetitiveness, awkward posture, vibration, or poor task design might be present and trigger more in depth evaluation. If problem areas are identified, follow-up evaluation with job task analysis is appropriate. Interventions that target these root causes (proactive) can result in more effective interventions that eliminate the injury and consequential disability.

Theoretical Basis for Disability Instrument Use

There is a theoretical basis that suggests disability instruments may be appropriate for detecting MSDs. In addition to workers' perceptions of symptoms, functional status includes the effects of the physical environment and cognitive adaptation. Functional status includes factors that are not represented in symptom status, such as, personality, motivation, social and economic supports. A model combining biomedical theory (biological, physiological) and social science (social structures, institutions) shows greater integration of causative factors and more complex interactions moving from cellular to individual to interaction with society (Figure 3.1).³⁵ Instruments that measure disability may detect problems earlier, and relate them more clearly to workers' experience of MSDs than clinical measures.³⁶ Symptoms that occur early in the disorder may not result in conditions that the worker perceives as interfering with work, leisure, or activities of daily living.³⁷ Functional and health status instruments are more reproducible³⁸ and can better discriminate among levels of severity, predict subsequent disability, and estimate future hours worked than physical examination or laboratory measurements.^{36,39-41} There is weak concordance between measures of MSD problems including clinical measurements like grip strength, and

range of motion,⁴⁰ physical exams, symptoms surveys, nerve conduction studies, and work histories.^{17,42} Functional disability instruments that are sensitive to problems in active workers may provide a means to identify those who may benefit from intervention before physiological responses to injury become severe.^{27,28,43}

A limitation of functional disability instruments is that they do not directly address the underlying physiological upper extremity MSDs. Measuring symptoms closely related to the disorder, like pain and numbness in CTS, have been argued to be more responsive to clinical treatment than more distant measures of functional disability.⁴⁴ Functional disability scales are intended to measure disability as perceived by the individual.⁵⁶ Therefore, as a surrogate for the underlying disorder, they are inherently imperfect and may be confounded by other factors. Even though a person has an upper extremity MSD, and is impaired, he or she may not be disabled. For example, disability scales may be influenced by the relationship between workers and supervisors, workers culture, coping style, economic pressures, medical care, availability of modified work, or misunderstanding about how the information will be used.⁵⁷ Furthermore, the same change in symptom or impairment in two workers could result in quite different perceptions of the change in disability. This is partly due to individual preference concerning the value of the change.⁵⁸ However, others have found disability instruments to be good predictors of recovery.³⁶ Baseline functional status of the hands is a significant predictor of work absence at 6, 18, and 30 months, and should be a primary target for intervention.⁴⁵ Depending on ones view, disability could be considered a principal goal of prevention and recovery and measured directly.^{3,17}

Once identified through screening, many work-related MSDs can be prevented through appropriate intervention.^{28,46,47} For example, 126 independent Ohio companies implemented engineering controls designed to decrease worker exposure. This program reduced lost workdays by 42%.⁴⁸ Prevention is an effective management tool for medical, social, and economic loss.^{15,49,50} However, implementation of such prevention intervention has been delayed partly as a reflection of governmental priorities,⁵¹ as well as business requirements for stronger evidence of causal relationships between exposure, disability, and the effectiveness of safety regulation and intervention programs.⁷ Validation and demonstration of accurate instruments for early MSD detection may facilitate epidemiological studies, and workplace safety program evaluation, and strengthen prevention by improving the focus for ergonomic workplace design, referral for medical management, job modification or job reassignment.

Screening Tool

The 11-item QuickDASH was derived from a longer 30-item instrument, the Disabilities of the Arm, Shoulder and Hand (DASH).⁵² The QuickDASH was developed to provide a measure of disability that has low administrative burden, and is quick to score and interpret. The score ranges between 0, no disability, to 100, severely disabled. The 30-item (longer) DASH has been validated on patient populations to assess treatment and in epidemiologic studies.^{52,53} It was found to be valid, reliable, and responsive to change for patients with upper extremity musculoskeletal disorders.^{52 53} The DASH was developed to quantify physical disability and symptoms for the entire

upper extremity region. It is intended for use in workplaces as well as clinical settings, and for acute and chronic disorders.

The QuickDASH was developed to provide a measure that has low administrative burden, and is quick to score and interpret. QuickDASH items include difficulty with everyday activities, work, household chores, washing back, recreational and social activities, sleeping, pain severity, and tingling, among others. Validity of the QuickDASH to assess upper extremity MSD disability in working populations was supported in findings from chapter 2. I found a statistically significant trend of increasing QuickDASH scores with increasing levels of upper extremity symptom severity, and significantly higher QuickDASH scores for workers with a diagnosis versus those without a diagnosis.

An optional high performance work module, that was designed to be given with the QuickDASH, was developed. This four question module asks questions concerning using usual work techniques, and completing work in the usual time with the usual quality. The work module was created to identify difficulties in high performance jobs that may not be reflected in items in the QuickDASH which address activities of daily living.⁵² Items have responses 1 through 5 and are transformed into a score of 0 through 100, with 0 indicating no disability. The work module is scored separately from the QuickDASH. More information about the QuickDASH and the Work Module is available at www.iwh.on.ca.

Regional instruments

A strength of the QuickDASH is that it focuses on a region of the body. Instruments that cover multiple disorders and body parts are efficient tools for surveillance programs. Regional instruments that cover multiple body parts can be used to assess several disorders in a population, as well as the combined effect of several disorders in one individual. Many items in musculoskeletal disorder and joint specific instruments of the upper extremity are applicable to the entire region. Thus it is possible to collapse multiple assessments into a single instrument.⁵⁴ Furthermore, within a group of workers, with similar musculoskeletal hazards, several different MSDs occur in different individuals, making evaluation of a group of disorders preferable to a single disorder.⁵⁵ Regional instruments can expand the range of information integrated for the assessment of disability by drawing from several disorders and body parts in combination. As a surveillance tool, a single instrument can be useful where using several instruments is impractical.

Measures of specific disorders may be more sensitive for early detection and severity assessment. Specific joint or disorder measures may also point to different causal factors than higher level disability instruments.^{17,54} This may not be relevant in general surveillance programs, but should be considered for intervention evaluation. Given the large number of case definitions for upper extremity MSDs, disability scales that are more distant from the physiological disorder may be more stable. Thus, disability scales may be more useful for comparisons across studies, for program

analysis, and for trend analysis in surveillance programs. Although, disability may not be sufficiently sensitive to changes in risk factors in small worksites.

This study investigates the accuracy of a new disability instrument, the QuickDASH, for workplace upper extremity MSD screening. Data gathered through a study being conducted by the Safety and Health Assessment and Research for Prevention program in Washington State (SHARP) provides an opportunity to examine the accuracy of the QuickDASH as a screening instrument in the workplace. These data include an extensive set of health indicators for upper extremity musculoskeletal disorders, psychosocial factors, workplace organizational factors, and detailed hazard exposure assessment.

Methods

Workers were assessed at baseline to determine if they had upper extremity symptoms. Workers with symptoms were given the QuickDASH and the optional work module. I evaluated the accuracy of the baseline QuickDASH and work module to identify workers with or likely to develop upper extremity MSD problems at baseline, 4-months, and 1-year. I tested the QuickDASH against several measures suggested as important markers for successful MSD screening programs,²¹ including upper extremity MSD diagnosis, lost workdays, obtaining medical care, change of job, light or restricted work, and severe or very severe symptoms. Severity of symptoms was measured on a 5-point scale of none, mild, moderate, severe, and very severe.

Baseline and follow-up data for this prospective study were collected between January 2002 and July 2003. The study was approved by the Washington State Institutional Review Board.

Data

Data for this analysis is from an ongoing prospective study, conducted by the Safety and Health Assessment and Research for Prevention (SHARP) program at the Washington State Department of Labor and Industries, in 13 workplaces in western Washington. The purpose of the SHARP study is to evaluate the relationship between work-related risk factors and the development of non-traumatic upper extremity MSDs. The workplaces participating in the SHARP study include hospitals, a sawmill, manufacturing firms, a plywood mill, and a medical research organization. To participate in the SHARP study, a firm needed to have a minimum of 200 full time equivalent workers at the site.

A total of 759 workers provided baseline information for the SHARP study. Of these workers, 559 (74%) had some upper extremity problem in the previous week and were administered the QuickDASH (Table 3.1). Among the workers who provided information for the QuickDASH, 388 completed a 4-month follow-up survey, and 294 completed a 1-year follow-up survey.

Outcome Measures

I assessed the accuracy of the QuickDASH as a screening tool by evaluating the baseline score against several outcome measures (Table 3.2) at baseline, 4-months, and 1-year. For lost workdays, job change, light or restricted work, and obtaining medical

care, data was gathered at baseline and 1-year follow up. For upper extremity MSD diagnosis and symptom severity, data was collected at baseline, 4-months, and 1-year follow-up. Interviewers administered questionnaires regarding health history, symptom frequency, duration and severity that were used in establishing a symptoms-based case definition. The QuickDASH was also interviewer administered at the same time to assess functional disability in those with symptoms during the prior seven days.

Diagnosis was determined for specific upper extremity musculoskeletal disorders based on physical examination, health history, nerve conduction studies, self-reported symptoms, and other information following criteria previously described.⁵⁹ Symptom severity at baseline and at 1-year follow up was elucidated with questions such as “In the past week, how would you rate the symptoms in your neck at its worst?” A similar question, with body part specified, was asked for each body part, shoulder, neck, elbow, and wrist/hand. At 4-month follow-up, workers were instructed to circle the number that best described how their symptoms were in the past week for each of the four body parts noted above. The symptom questions have a 5-point severity scale and are the same for each question.

Data Analysis

I evaluated the accuracy of the QuickDASH and the optional work module by analyzing sensitivity, specificity, and receiver operator characteristic (ROC) curves with respect to the outcome measures described above. All measures were assessed at baseline, 4-months, and 1-year where data were available (Table 3.2).

The predictive value of a positive test ($PPV=P(D+|T+)$) is the probability that a worker with a positive test actually has the disorder. The predictive value of a negative test ($NPV=P(D-|T-)$) is the probability that a worker testing negative actually does not have the disorder. These predictive values are based on the sensitivity ($sens.=P(T+|D+)$), specificity ($spec.=P(T-|D-)$), and the prevalence of the disorder in the population studied. The higher the predictive value the more useful the test is to aid clinicians in determining an appropriate course of treatment or in aiding workplace managers in selecting the appropriate level of intervention.

I used ROC curves to plot the sensitivity vs. 1-specificity of the QuickDASH as a method of assessing its performance. The ROC curves provide a graphical representation of the test performance across all possible QuickDASH scores. The greater the area under the curve the better the global performance of the test (Figure 3.2).⁶⁰

A cut point or 'threshold score', indicating a positive or negative 'test' is needed to analyze sensitivity and specificity. Because the QuickDASH is a new instrument the interpretation of its scores is not yet established. Thus, I used a previously demonstrated method for choosing when to declare the results positive or negative.^{34,52} The method is based on the cross-sectional precision of the baseline QuickDASH score. This provides a way to be reasonably confident a score is truly above zero. The cross-sectional precision is a range of QuickDASH scores within which the true score falls. The cross-sectional precision is derived from the standard error of measurement (SEM). The SEM is the variation around the observed score and is computed as $SEM = SD * \sqrt{1 - R}$,

where R is the reliability coefficient Cronbach's alpha.^{34,61} Cronbach's alpha is the internal consistency in terms of the degree of intercorrelation among items in the QuickDASH.⁶² The SEM is multiplied by ± 1.96 to obtain the 95% confidence interval when added to or subtracted from the worker QuickDASH score. A QuickDASH score larger than the cross-sectional precision value was selected for the threshold score in order to be 97% confident that the workers' true score differs from 0.

Results

Of the 759 baseline participants, 559 workers had some upper extremity symptom in the past week and completed the QuickDASH. These workers were, on average, 40 (SD 11) years old; 44% were male (Table 3.1). At baseline, 537 symptomatic workers reported an average of 5.1 (SD 6.4) and median of 3.7 (IQR 0.1-35.4) years with upper extremity symptoms. At baseline, 34% of workers had a concurrent health condition, confirmed by a medical doctor that could contribute to MSD risk. Among the outcome measures, the baseline prevalence of diagnosis and medical treatment was highest at 37%, and the change in job due to upper extremity MSD had the lowest prevalence at 8%. One-year prevalence of diagnosis and medical treatment was 31%, and change in job was lowest at 6% (Table 3.3).

The mean QuickDASH score at baseline was 16.7 (SD 16.2), with a median of 11.4 (IQR 4.5-25.0). The QuickDASH score was skewed with 11% of workers having a score of 0, and an additional 11% having a score of 2.3. The cross-sectional precision, as measured by the standard error of the mean, was 5.7, with a 95% confidence interval of ± 11.3 . A QuickDASH score of 11.4 served as the cutpoint score for sensitivity and

specificity analysis, implying one could be 97% confident that a worker's score of 11.4 is truly above 0. Cronbach's Alpha was 0.87 indicating good internal consistency. Similarly, the optional work module had a standard deviation of 17.0, and alpha of .89, resulting in a standard error of the mean of 11.1. The same cutpoint score of 11.4 was used for the work module and the QuickDASH.

QuickDASH accuracy for upper extremity MSD diagnosis, and symptom severity at baseline measured by sensitivity was 73% and 96%, while specificity was 56% and 53% respectively. For purposes of analysis, symptom severity was dichotomized with none, mild, and moderate in the low severity group, and severe and very severe in the high severity group (Table 3.2). Lost workdays, obtaining medical care, and use of light or restricted work were also dichotomized for analysis. Baseline QuickDASH accuracy for classifying workers based on lost workdays, light or restricted work, and job change exceeded 70% sensitivity, but had specificities of 48% (Table 3.4). Baseline QuickDASH accuracy for obtaining medical treatment was 67%, with specificity of 52%. At 4-month follow-up the QuickDASH classified workers' symptom severity, as sensitivity 77%; and specificity 54%, and for diagnosis; sensitivity 65%, and specificity 49%.

One-year follow-up accuracy for upper extremity MSD diagnosis, and symptom severity was sensitivity 72% and 86%; specificity was 54% and 52%, respectively. At 1-year follow-up light work and job change had sensitivities of 73% and 78%, respectively, but had specificities of 48% (Table 3.4).

Though QuickDASH data for the 4-month and 1-year follow-up intervals was incomplete, the QuickDASH scores are reported. There were 198 workers (of 559) that had both baseline and 1-year follow-up QuickDASH scores. For this group (n=198) baseline mean was 18.1 (SD 15.9) and 1-year mean was 19.0 (SD 18.3). The baseline 25th, 50th, and 75th percentiles were 6.8, 13.6, and 25, respectively. Similar percentiles at 1-year follow-up were 4.5, 13.6, and 27.3, respectively.

The QuickDASH ROC area of 0.87 for classifying workers by symptom severity at baseline indicates that 87% of the time a randomly selected individual from the severe symptom group has a higher QuickDASH score than a randomly selected individual from the low severity symptom group. The better the performance of a QuickDASH score in correctly classifying workers the closer the ROC curve is to the upper left corner.³⁴ The ROC areas for the baseline performance of the QuickDash for diagnosis and job change were 0.70, and lost workdays 0.64 (Figure 3.2). At 4-month follow-up, ROC areas for symptom severity were 0.74, and diagnosis 0.63. At 1-year follow-up the ROC area was 0.75 for symptom severity. All other ROC areas at 1-year were between 0.60 and 0.70. These results will be useful for comparing the performance of the QuickDASH to other instruments when that information becomes available.

For all outcome measures positive predictive value was greater at baseline than at 4-month or 1-year follow-up. At baseline, positive predictive value for upper extremity MSD diagnosis was 50% and negative predictive value was 78%. Baseline positive and negative predictive value for severe or very severe symptoms was 27% and 99% respectively. Positive and negative predictive value at 1-year follow-up, as

predicted by the baseline QuickDASH score, for musculoskeletal disorder diagnosis was 41% and 82% respectively. For severe or very severe symptoms, positive and negative predictive value was 26% and 95%, respectively (Table 3.4).

Of the 559 workers that completed the QuickDASH at baseline, 533 completed the optional work module. The mean baseline work module score was 11.6 (SD 17.0), with a median of 0 and an interquartile range of 0 to 19. Scores ranged from 0 to 100, with 258 workers (51%) having a score of 0. Internal consistency was good with a Cronbach's alpha of 0.89. Sensitivity for baseline upper extremity MSD diagnosis was higher for the QuickDASH, 73%, than for the work module 50%, while specificity was 56% for the QuickDASH and 70% for the work module. Similarly, sensitivity and specificity for MSD diagnosis was 72% and 54%, respectively, for QuickDASH, and 39% and 69% for the work module (Table 3.5). On average, across all outcomes and follow-up periods, the ROC curve area was 7.4 points larger for the QuickDASH than for the work module.

There were 201 workers that had both baseline and 1-year follow-up work module scores. Baseline mean was 10.7 (SD 16.0) and 1-year mean was 12.0 (SD 18.6). The baseline and annual 25th, 50th, and 75th percentiles were 0, 0, and 18.7, respectively.

Discussion

This study has examined the accuracy of the QuickDASH as a screening tool to identify upper extremity MSDs in a worker population. The study's findings suggest that the QuickDASH may be useful as a screening tool to identify workers with

symptoms who may have or are likely to develop disability due to upper extremity MSDs.

It is possible to compare findings reported here for the QuickDASH to other instruments. However, these comparisons have limited meaningfulness because direct comparisons cannot be made. One comparison is with the NIOSH symptom survey. The QuickDASH classified workers at baseline for severity of symptoms with sensitivity of 96% and specificity of 53%. Baron used components of the NIOSH symptom survey, pain frequency, duration, and intensity, to classify 287 workers reporting hand discomfort in the past 7 days.⁶³ Those reporting pain were asked to complete the questionnaire. Pain levels that fell above the median of the group score for frequency, duration or intensity were considered a positive test. These test results were compared with abnormal findings from physical examination of the hands, with resulting sensitivity of 71% and specificity of 72%.

The QuickDASH demonstrated a sensitivity of 73% and specificity of 56% in classifying workers by diagnosis at baseline. The Nordic Musculoskeletal Questionnaire was used to classify workers by clinical diagnosis.¹⁸ Aches, pains, or discomfort of the upper extremity in the past 7 days was reported by them. Among 165 female workers, accuracy was calculated for each upper extremity body part. Sensitivity and specificity were 92% and 39%, respectively, for the shoulder, 79% and 20% for the elbow, 67% and 27% for the hand, and 66% and 33% for the neck. Across the neck, shoulders, elbows, and hands positive diagnosis was determined for 75 women. Additionally, at least one positive item concerning aches, pains, or discomfort of the upper extremity in

the past 7 days was found for 94 women. Using any positive finding, diagnosis or positive item concerning aches, pains, or discomfort, as a positive test to predict diagnosis of an upper extremity MSD, sensitivity was 83% and specificity was 64%. Performance comparisons to other instruments for lost workdays, change in job, light duty, or seeking medical care, have not been published.

The accuracy of the optional high performance work module in a prospective study has not been previously reported. There was high correlation between the work module score and the QuickDASH scores of 0.69 ($p < .001$). Sensitivity was higher and specificity was lower for the QuickDASH than for the work module for all outcomes and all follow-up periods (Table 3.5). The QuickDASH had larger ROC curve areas for all outcomes and all follow-up periods indicating better overall performance of the QuickDASH. This may happen because workers report disability in activities outside of work more readily than disability with work. For example, in the present study 51% of workers reported interference with activities outside of work because of MSD symptoms, although, only 33% reported that MSD symptoms interfered with the pace or quality of their work. A number of factors may encourage a worker to remain on the job and not report injuries, including their perception that the injury is not serious, workdays would not be missed,¹¹ fear of reprisal, desire not to lose their usual job, performance evaluations may be partially based on recordable injury goals, the belief that pain is a normal part of the job.⁶⁴ These factors may also contribute to underreporting disability on the job, or continuing to work with symptoms. This study

found many workers with MSD symptoms continued to work: 15% had severe or very severe MSD symptoms in the last week, and 37% had moderate symptoms.

The predictive values established by this study may be underestimated. The positive predictive value of a QuickDASH score for symptom severity at baseline was 27% in the present study. Predictive values are influenced by the prevalence of disability in the study population. Biased results may have resulted because some workers may not have been available to participate in the study because they left work due to MSD related disability (survivor bias). The contribution of bias cannot be determined because the number of those not working due to MSD related disability is unknown. However, if the baseline prevalence of severe or very severe symptoms was 20% in this population, instead of 15%, the PPV would be 34% instead of 27%, holding sensitivity and specificity constant.

The ROC curve area provides the probability of correctly classifying individuals across all possible pairs of sensitivity and specificity values across all QuickDASH scores.⁶⁰ ROC analysis can be used to help determine the most useful threshold score. A threshold score or, cut point, is the QuickDASH score above which I classify a worker as abnormal, test positive, and below as normal, test negative. Generally, the point at which the ROC curve is the closest to the top left corner of the graph is the test score that correctly classifies workers with the least error (Figure 3.2).³⁴ Depending on the consequences of false-negative test results, different threshold scores can be selected based on sensitivity and specificity across the range of scores. Different threshold scores may be preferred when using the test in populations with a different prevalence

of disease.⁶⁰ With a higher prevalence, a higher threshold score may be desirable to lower the number of false-positive tests. For epidemiological studies a threshold score which maximizes the precision of the estimate may be preferred.⁶⁵

The QuickDASH was not sensitive in detecting differences among the 22% of workers that scored near the least disabled with scores of 2.3 and below. This indicates a floor effect for the QuickDASH in this population of symptomatic workers. The floor effect suggests that QuickDASH has a weak ability to distinguish between disability levels at the low end of the scale.

The internal reliability and the cross sectional precision of the QuickDASH are very good, with alpha of 0.87, SEM of 5.7 with a 95% CI of ± 11.3 . This performance is slightly below that of the 30-item DASH, alpha 0.96, SEM of 4.4, and CI of ± 8.8 points.⁵²

Few instruments have been developed for measuring functional disability of the neck and upper extremity among workers on the job.⁶⁶ The Neck and Upper Limb Index (NULI) has been demonstrated to have good internal consistency (Cronbach's alpha 0.90) and test-retest reliability (intraclass correlation coefficient 0.88).⁶⁷ The relevance and comprehensiveness of functional disability instruments for evaluating work-related MSDs has been reviewed.¹ However, I am not aware of any publications that investigate the accuracy of other disability instruments in working populations. Functional disability instruments have been demonstrated to be reliable, valid, and responsive in populations of patients as discussed in chapter 2. The Upper Extremity Function Scale score was associated with symptom severity, measured on a 6 point

scale, among carpal tunnel syndrome patients at baseline (Pearson r 0.36, $p < 0.001$).⁴⁰ Comparatively, the baseline QuickDASH score in the present study had a stronger correlation with symptom severity (Pearson r 0.71, $p < 0.001$).

The larger SHARP study was not designed to provide data for instrument validation, and QuickDASH scores were not collected from workers without some musculoskeletal complaint. Thus, the evaluation of floor effects cannot be fully assessed. Likewise, the accuracy of the screening test to identify those without MSDs cannot be tested by this study. However, my estimates are likely to be conservative. By adding workers with no MSD complaints (no disease) and low QuickDASH scores (negative test), specificity would be increased without a reduction in sensitivity. Sensitivity would not be affected because workers without MSD problems in the previous week are unlikely to have positive values on outcome measures.

The ethical use of disability information is critical for successful surveillance programs. Employees' trust in the way management will use data and with whom the data will be shared is essential to ensure accurate data collection. Forms should not include the workers name, and participation should be voluntary in nature.³² Surveillance may be effectively implemented through the sampling of jobs or departments without requiring information from every worker. Individual injury rarely occurs in isolation. Evaluation at the job or department level can facilitate the identification of organizational or ergonomic factors that often are the underlying causes of injury. Guidelines to support the ethical use of data include the use of qualified health professionals that are independent and impartial, assurance of

confidentiality of individual health information, results relate to the program purposes, consequences for workers' health and livelihood need to be considered, and program purposes clearly communicated to all.⁶⁸

Caution should be exercised in using this instrument for individual level evaluation. In the present study, the QuickDASH does not meet recommendations of precision for assessing individual level disability. Cronbach's alpha for the QuickDASH is 0.87, which is below the 0.90 minimum recommended for individual-level application.⁶⁹ The accuracy of the QuickDASH does not provide confidence intervals narrow enough to give a true measure of functional status for individual level decisions. As a screening tool, the QuickDASH may provide a trigger for appropriate follow-up along with more in-depth questionnaires, targeted physical exams, and health risk surveillance.

Conclusion

The QuickDASH provides an efficient instrument for identifying those with or likely to develop upper extremity MSDs, and may be used to target early workplace intervention for the prevention of upper extremity MSD disability. Detecting musculoskeletal problems early through effective screening and implementation of workplace prevention is critical to reduce costs and morbidity. The QuickDASH minimizes the administrative burden, which makes the instrument practical for screening, epidemiologic studies, program evaluation, and worker education. This study indicates the accuracy of the QuickDASH is adequate to detect upper extremity MSDs and classify symptomatic workers for follow-up.

Table 3.1. Baseline characteristics of the study population

Characteristics		No.	%
Age	18-29	111	(20)
	30-39	147	(26)
	40-49	166	(30)
	50-64	135	(24)
Male		246	(44)
Race	White not Hispanic Origin	358	(64)
	Asian or pacific Islander	102	(18)
	Hispanic	56	(10)
	American Indian, Alaskan Native	20	(4)
	Black not Hispanic Origin	17	(3)
	Other, Unknown	6	(1)
BMI kilograms/meters ²	<20	23	(4)
	20-25	196	(35)
	>25-30	172	(31)
	>30	149	(27)
Current smoker		161	(29)
Years of symptoms *, median (range)		3.7	(0.1-35.4)
Years in job, mean (SD)		6.6	(7.1)

Table 3.1. continued

Characteristics	No.	%
Previous upper extremity MSD diagnosis		
ruptured disk in their neck	7	(1)
carpal tunnel syndrome	51	(9)
thoracic outlet syndrome	3	(0.5)
hand or wrist tendinitis	65	(12)
epicondylitis	35	(6)
rotator cuff syndrome	30	(5)
trigger finger	8	(1)

* Years of upper extremity MSD symptoms at baseline for the longest duration problem across neck, shoulder, elbow/forearm, and wrist/hand.

Table 3.2. Outcome measures for assessing the screening accuracy of the QuickDASH.

Variables	Description	Collection period
Diagnosis	Specific upper extremity musculoskeletal disorders based on physical examination, health history, nerve conduction studies, grip and pinch force, and self-reported symptoms ⁵⁹	baseline, 4-months, 1-year
Symptom severity	Maximum across 4 body parts; neck, shoulder, elbow/forearm, wrist/hand. Individual item response are, none (0), mild (1), moderate (2), severe (3), and very severe (4). I also used a dichotomous variable 0 through 2 = 0, 3 and 4 = 1.	baseline, 4-months, 1-year
Lost workdays	In the past 12 months, how many days have you missed work because of your (neck) problem?	baseline, 1-year
Change in job	Did you change from another job to your current job to avoid more neck problems?	baseline, 1-year
Light or restricted work	In the past 12 months, how many days have you done light or restricted work because of your neck problem?	baseline, 1-year
Obtaining medical care	In the past 12 months, how many times have you seen a health care provider (doctor, nurse, physical therapist) for this neck problem?	baseline, 1-year

Table 3.3. Descriptive information for outcome variables

	Baseline		4-month		1-year	
	n	%	n	%	n	%
Diagnosis	207	37.0	104	26.8	90	30.6
Symptoms *	85	15.2	109	28.1	49	16.7
Lost Work Day	71	12.7	-	-	29	9.9
Medical	204	36.5	-	-	90	30.6
Treatment **						
Change Job	46	8.2			18	6.1
Light Work	77	13.8	-	-	30	10.2
Total ⁺	559	-	388	-	294	-

* Symptoms, are positive for severe or very severe upper extremity problems in the last 7 days

** Medical Treatment, indicates the worker has obtained medical treatment in the last year for upper extremity MSD problem.

⁺ The number of workers declines for 4-month and 1-year follow up periods because the entire cohort had not yet been followed-up.

Table 3.4. Measures of QuickDASH performance for each time period

Outcomes	Sensitivity	Specificity	PPV	NPV	ROC area
<u>Baseline</u>					
Symptoms	96.5	52.7	26.8	98.8	87
Diagnosis	73.4	56.2	49.7	78.3	70
Lost Work Days	73.2	47.9	17.0	92.5	67
Med. Treatment	66.7	52.1	44.4	73.1	64
Change Job	84.8	47.9	12.7	97.2	70
Light Duty	72.7	48.1	18.3	91.7	64
Pace or Quality	81.5	58.4	49.0	86.6	76
<u>4-Month Follow-up</u>					
Symptoms	77.1	54.1	39.6	85.8	74
Diagnosis	65.4	49.3	32.1	79.5	63
<u>1-Year Follow-up</u>					
Symptoms	85.7	52.2	26.4	94.8	75
Diagnosis	72.2	54.4	41.1	81.6	67
Lost Work	69.0	47.5	12.6	93.3	63
Med. Treatment	65.6	51.0	37.1	77.0	64
Change Job	77.8	47.5	8.8	97.0	64
Light Duty	73.3	48.1	13.8	94.1	65
Pace Quality	75.3	54.0	38.4	85.2	71

Table 3.5 Measures of Work Module performance for each time period

Outcomes	Sensitivity	Specificity	PPV	NPV	ROC area
<u>Baseline</u>					
Symptoms	73.2	68.8	29.0	93.6	76
Diagnosis	49.8	69.9	49.3	70.2	61
Lost Work Days	59.4	65.7	19.8	91.9	65
Med. Treatment	47.3	68.3	46.4	69.1	58
Change Job	48.9	63.6	10.6	93.3	58
Light Duty	55.8	65.5	20.8	90.2	61
Pace or Quality	67.0	77.1	58.9	82.7	75
<u>4-Month Follow-up</u>					
Symptoms	50.0	68.9	38.6	78.0	60
Diagnosis	40.8	65.2	30.0	75.1	55
<u>1-Year Follow-up</u>					
Symptoms	53.1	70.5	26.3	88.2	60
Diagnosis	38.9	69.5	36.1	71.9	54
Lost Work	51.7	68.6	15.3	92.8	62
Med. Treatment	46.7	72.4	42.9	75.4	61
Change Job	38.9	66.9	7.14	94.4	51
Light Duty	50.0	68.4	15.3	92.3	61
Pace Quality	56.8	75.5	46.9	82.8	67

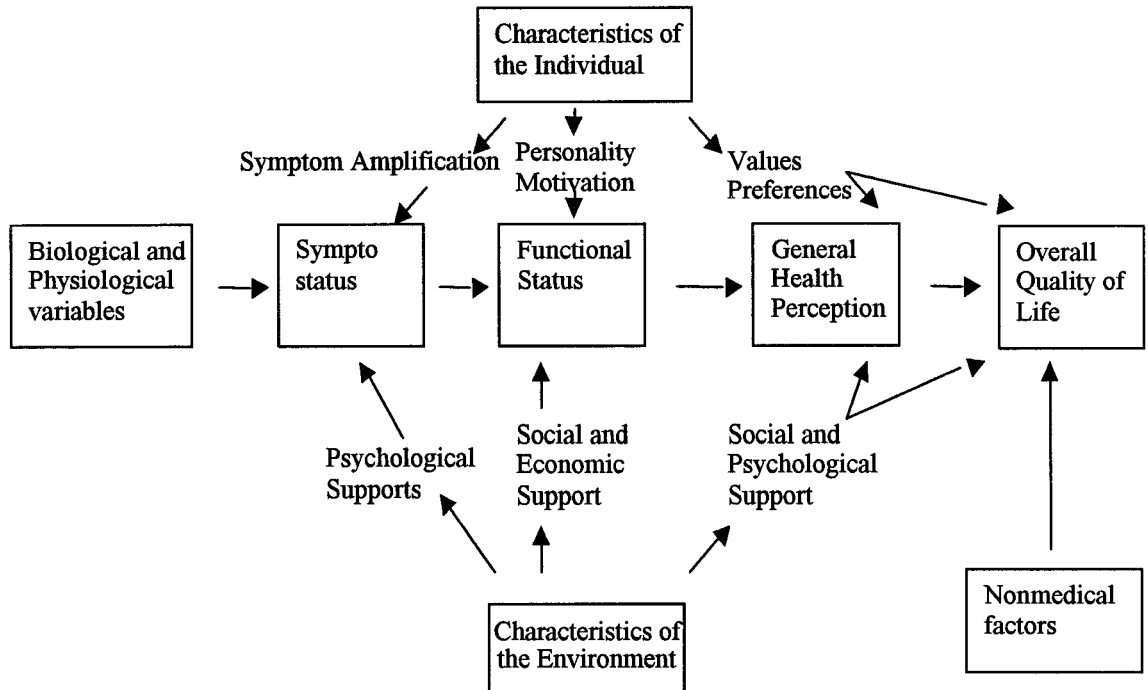


Figure 3.1. Conceptual Model for Causal Factors in Work Related Musculoskeletal Disorders (adapted from Wilson³⁵)

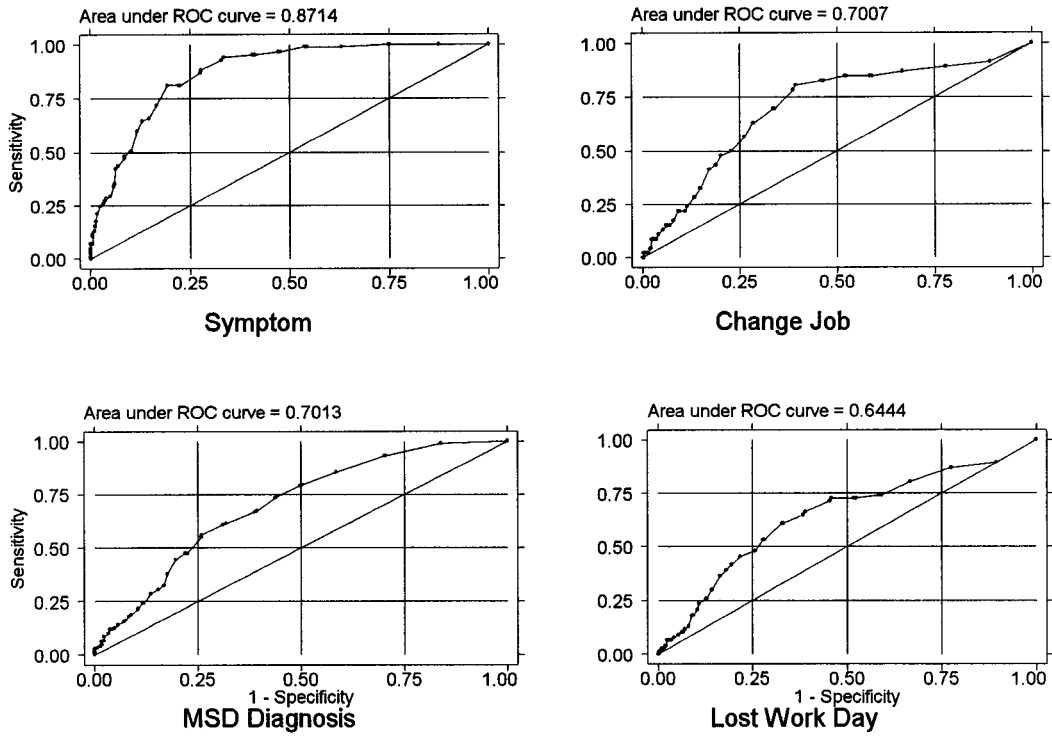


Figure 3.2. Receiver operating characteristic curves of QuickDASH performance in classifying workers for the best four outcome measures at baseline.

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Chapter 4: Prognostic Factors Of Long-term Disability In A Worker's Compensation System

Introduction

The burden of workplace injury and illness is significant, with 10% of the population having work disability at any one time.¹ Workplace injuries cost \$129 billion dollars in 1992, and resulted in 2.7 million disabling work injuries that qualified for workers' compensation indemnity benefits.² There are also consequences for workers, families, and society which are not reflected in these expenditures of medical costs, lost time at work, insurance administration, fringe benefits, or worker replacement and retraining.^{1,3} These include diminished future work activity, pain, interrupted careers, disruption in family relationships, reduction in household production, reduced community involvement, and diminished quality of life.^{2,4} There is also the lost opportunity to invest these resources for productive uses. Workers' compensation systems cover 45% of direct costs (medical and insurance administration costs), and 27% of all costs of occupational injuries and illnesses.² Private health insurance covers 18%, public funds cover 24%, and workers pick up 13% of the direct costs.²

This study identifies factors in a state workers' compensation system that can be measured early in the course of work time loss that predict long-term disability. Identifying factors that predict long-term disability is important because a small percentage of disability claims account for the majority of costs.^{5,6} Furthermore, as the length of time away from work increases, the probability of returning to regular work decreases.^{7,8} Therefore, identifying predictors of disability soon after the injury may

reduce the disability burden if appropriate interventions are made. Research in developing prognostic indicators that can guide decisions concerning return-to-work has been recommended by the National Academy of Science and others.^{4,9,10} This study identifies predictors of long-term disability in order to provide information for targeting resources to high risk claims cases with the aim of reducing disability and return-to-work time.

Although studies are needed to corroborate some study findings, research suggests that disability can be reduced through a variety of approaches. Disability prevention can be achieved through workplace interventions, health care delivery organization, or workers' compensation policies. With timely referral, improved physician training, and improved care coordination, the incidence and duration of disability can be reduced.^{9,11} A reduction of disability duration can be achieved through intensive case management practices. For example, more involvement of health care providers can lower work related disability by 30 to 50 percent by improving injured workers' transition back to work.^{12,13} The health care providers can be instrumental in assisting the employer and worker in identifying workplace hazards and finding modified duty work to safely transition the employee back to work. Improved communication among health care providers, employees, case managers, and employers can clarify realistic expectations for recovery and establish timelines for return to work. Improved communication combined with early treatment and rehabilitation may reduce cost and disability.⁴ Activities aimed at reducing the risk of upper extremity musculoskeletal disorders were more than 6 times as frequent when recommended by

the treating physician compared to no physician recommendation.¹⁴ Secondary prevention programs for back pain have demonstrated good returns on investment costs. Multi-component approaches to improving outcomes have been successful.¹⁵ These programs typically employ multiple interventions including exercise, health education, ergonomic awareness, coping strategies, and others. However, the specific factors and their relative influence on reduction in disability are not clear.¹⁶

OSHA and state agencies responsible for regulation of health and safety may use predictors of disability to target workplace inspections. Inspection can reduce the incidence of compensable workers' compensation claims¹⁷ and presumably reduce re-injury rates for returning workers. For example, information concerning the contribution to length of disability of factors included in the present study like injury type, injury severity, industry, occupation, company size, and time between injury date and treatment may provide general guidance for targeting inspections.

Understanding prognostic factors is critical to evaluation of rehabilitative interventions. When evaluating the performance of intervention programs aimed at reducing long-term disability, it is necessary to control for factors that contribute to disability in order to understand the effect of the interventions being studied.¹⁸

Understanding the contribution of prognostic factors is important to treatment development and reduction of disability even though clinical understanding is not very complete for some disorders.

Workers' compensation administrative data are collected for the primary purpose of managing work related injury and illness claims. Though limited,

administrative claims data do include information that may be useful for predicting disability. Furthermore, such data are available soon after claim filing, and avoids the expense of collecting primary data. If factors that predict long-term disability can be identified using existing data, interventions targeting those cases may be implemented as a claims management tool.

As changes occur in the workplace the predictors of disability also change, providing a need for ongoing research in this area. This study is, in part, an update to a study done in 1994 investigating predictors of long-term disability using similar data.⁷ The makeup of the workforce, and work methods have changed over time, resulting in differences in the frequency and type of workplace injuries and illnesses. For example, new technology has increased exposure to keyboarding. Increased cycle time for many processes in manufacturing, and union protections have declined. The workforce is getting older, with the percentage of women and minorities increasing.⁹ The incidence of musculoskeletal disorders has declined significantly less than other claims over the past decade.¹⁹ In the Washington State fund, overall claims decreased by 4.9% per year while two musculoskeletal disorders, epicondylites and rotator cuff syndrome, increased by 1.5% and 0.5%, respectively. Musculoskeletal disorders comprised 47% of accepted claims during 1991 through 1999 including slips, trips and falls.²⁰

Methods

Data Source

This study used administrative data from the Washington State workers' compensation system. The data source was the Washington State Department of Labor

and Industries (DLI) Industrial Insurance Medical Information and Payment Systems. Two thirds of the non-federal workforce in Washington is covered by this state system. The remaining non-federal workforce is covered by firms that self-insure.²¹ Only those firms that participate in the State system have complete information about lost work time and complete claimant information; hence, self-insured firms are not included in this analysis. Records for workers' compensation claims accepted from January 1, 1997 through December 31, 1999 with 3 or more days of compensated lost workdays were used for this analysis. Data for the study were extracted from the DLI claims database in February 2004, which defined the end of the follow-up period. Thus, follow-up time was on average 5 years 9 months, with a minimum of 4 years 2 months and a maximum of 7 years 1 month. Subjects younger than 18 or older than 65 years at injury date were excluded. Workers were on average 37 years old (Table 4.1). If a worker had multiple claims during this period, the first claim was used for analysis. Only new claims and claims with more than three lost workdays were used. In Washington State, wage replacement is provided only when three or more days of lost work were incurred. Data concerning race and ethnicity are not collected in the worker's compensation system and thus are not available for analysis. 83,469 new time-loss claims, representing claimants who were out of work for more than three days due to injury, were identified in the three-year period. Of these, 20,150 (24%) were excluded because their time loss status could not be adequately confirmed or the claim record did not have complete information on all factors used to predict disability. All of the remaining 63,318 claims

were included in this analysis. The Washington State Institutional Review Board approved this study.

Variables

The outcome measure used for the Cox proportional hazard model was cumulative compensated lost workdays as a measure of disability. This measure is thought to represent disability from workplace injury and illness more fully than first return-to-work.²² Using cumulative compensated lost workdays as the outcome measure facilitates the evaluation of common patterns of multiple episodes of time loss due to injury and illness. The DLI computes lost workdays by dividing the aggregate wage replacement benefit amounts paid by the lost workday monetary value (per diem payment) assigned to each worker by the workers' compensations system. The per diem payment is calculated based upon a formula that considers marital status, number of dependents, weekly wage and the overall state average wage. The maximum per diem amount is approximately 80% of the overall state average wage. In Washington State, temporary disability wage replacement is provided to workers with occupationally related injury or illness with more than three lost workdays for a claim.

Predictor variables obtained from DLI claims database included claimant age, marital status, and number of dependents. These have previously been found to be associated with long-term disability.²²⁻²⁴ The number of days from injury to hospitalization has been used by others.^{7,24,25} It is measured as the lapsed days from injury to hospital admission date and used as a surrogate measure of injury severity with 28 or more days coded as 1. Company size, determined by the number of full time

employees at the end of the quarter in which the injury occurred, with 50 or more employees, coded as 1. Days between injury date and first medical visit is determined by the first medical service provided for the claim with 27 or more days and is coded as 1.²⁵ Industry categories represent OSHA Standard Industrial Classification divisions, with some categories combined to simplify analysis. Categories for occupation are based on the Bureau of Census major groups, with several combined to facilitate analysis. Unemployment rate was obtained from the Washington State Employment Security Department. I used the unemployment rate for the month and the county the worker resided in at the date of injury (table 4.1).

A variable indicating company participation in the DLI retrospective rating program (intended to reduce workplace injuries) was included in the analysis. Washington has a retrospective rating program to refund some of the workers' compensation insurance premium to employers who have average claim rates below other employers with the same risk classification, and who improve on their own claims experience from the previous year. Therefore, these companies have an incentive to reduce claim rates, and most try to improve prevention and health and safety programs and to develop programs to facilitate early return to work.

Injuries were categorized by combining ANSI z-16.2 codes. Upper extremity non-traumatic soft tissue musculoskeletal disorders (NTMSD) were classified by matching z-16 injury nature, injury type, and body part codes according to Silverstein.²⁶ The neck and back category include claims that involve the neck or back but do not meet the criteria for non-traumatic injury. Contusion or cut or scratch, fracture, and

sprain or dislocation categories includes those claims that have z-16 nature codes for those injuries. Injury codes that do not meet the criteria for other categories are included in the reference category. All variables in the present study have been reported to be associated with long-term disability by other investigators and are addressed more fully in the discussion section. Many other variables have been suggested to be associated with long-term disability^{27,28} but are not included in this administrative dataset.

Analysis

Three statistical models; logistic, quantile regression, and Cox proportional hazards, were used to assess the association between the dependent variable cumulative lost workdays, and the following predictors: worker characteristics, injury type, injury severity, firm size, industry, occupation, unemployment rate, and claim year (Table 4.2). Logistic regression focuses on the 20% of claims that have more than 6 month of cumulative lost workdays. Logistic regression provides the effect of each predictor as odds ratios (>6 months of cumulative disability = 1). The odds ratios give the probability of having 6 months or more of compensated lost work for each unit change for each covariate. Logistic regression has the advantage of generating results that are readily interpretable by most researchers and focuses on cases that have long-term disability. Exploratory investigation of interaction effects was carried out to determine if the predicted joint effect of key variables were different from the additive effects of the variables individually. Interaction (effect modification) is the modification of a predictive factor of interest (e.g. back injury) by another factor in the model (e.g. company size). Quantile regression was used to predict the 80th percentile of cumulative

lost workdays providing coefficients of the effect in day units. The 80th percentile is approximately 6 months of cumulative lost workdays. Cox proportional hazard regression (survival analysis) provides the effect of each predictor as hazard ratios of returning to work at any time (the risk of returning to work).

Survival analysis provides the hazard ratio (risk ratio) of ending disability, measured as cumulative lost workdays, at any given time. Hazard ratios less than one indicate lower likelihood of ending disability. Cox proportional hazard model assumes a predictor variable has a similar effect at any point in time (e.g. at 1 month, 2 months and so on). Cox proportional hazard (survival analysis) also provides a means to account for censoring, or incomplete data. In claims records this occurs where there is loss during follow-up due to the claimant's death, or time lost beyond the end of the follow-up period. I tested the proportional hazard assumption for the overall model and for each covariate using log-log curves and the observed versus predicted survival curves. The log-log curves ($-\ln(-\ln(\text{survival probability}))$) show each level of covariate versus $\ln(\text{analysis time})$ using STATA `stphplot`. I also compared the Kaplan-Meier observed survival curves with the Cox predicted curves for each covariate using STATA `stcoxkm`. The log-log plots gave generally parallel curves, indicating no evidence of violations of the proportional hazard assumption. These findings were supported by the closeness of the observed survival curves and the Cox predicted curves. STATA statistical program version 8 was used for analysis.

The analysis included Kaplan-Meier survival curve showing the relationship between percentage of claims and long-term disability.

Given the large number of claims in this analysis, there were many significant findings, so attention was given to the importance of the magnitude of the effect of predictor variables. To support the findings the same model was run for each claim year, 1997, 1998, and 1999. To be considered significant and stable, predictor coefficients needed to be significant each year, have the same sign, and be within 25% above or below the average coefficient for all three years (Table 4.2). This population based retrospective cohort study²⁹ provides a strong method for generalizing findings to the current Washington State workforce.

Results

The population in the present study was 70% male with 47% between 30 and 44 years old. Workers employed in services industries (23%) made up the largest industry category, followed by construction (20%). Companies with fewer than 50 full time workers made up 52% of the study population. Non-traumatic musculoskeletal disorders (NTMSD) comprised the largest category of injuries, with 23% having neck or back related NTMSDs and 17% having upper extremity NTMSDs. Most workers received treatment for their injury within 27 days of the injury (93%); (4%) were hospitalized within 28 days of their injury (Table 4.1).

The Kaplan-Meier curve shown in Figure 4.1 indicates the distribution of cases with differing lengths of lost work time due to injury. As shown, half of the workers had less than 1 month of disability, 70% of workers had less than 3 months of disability, and 80% had less than 6 months.

The logistic model found the strongest predictors of 6 months of cumulative lost workdays (disability) to be hospitalization within 28 days of injury (OR 4.3), age over 45 years, vs. less than 30 years (OR 2.0), back and neck injuries (OR 1.8), working in the construction industry (OR 1.8), and injury to first medical treatment of more than 27 days (OR 1.7) (Table 4.2). The strongest predictor of decreased disability was injuries involving contusions, cuts, or scratches (OR 0.6). Workers with acute back and neck injuries were 1.8 times as likely to have more than 6 months of lost workdays, as workers with other (reference category) injuries. The model explained about 5% (pseudo R^2 0.054) of the variance of more than 6 months of cumulative lost work. The logistic model correctly predicted 80% of the dependent variable outcomes. Predictive values indicate that half (PPV 51%) of those with 6 months or more of disability were correctly predicted by the logistic model, and of those with less than 6 months of disability the model predicted 81% correctly (NPV).

Effect modification (interaction) involves the modification of a predictive factor of interest by another factor in the model. For example, smoking modifies the effect of asbestos in causing cancer. In this study, two sets of variables had significant interaction in the logistic model predicting 6 months or more of compensated lost work: acute back and neck injury and gender, and construction industry and company size. Gender modified the effect of acute back and neck injury on 6 or more months of compensated lost work, with males having higher likelihood of disability. Female workers with acute back and neck injuries were more likely (OR 1.6, CI 1.4-1.8) to have 6 months or more of compensated lost work time than women with other injuries. However, among males,

those with acute back and neck injury were more likely (OR 1.9, CI 1.7-2.1) to have 6 months or more of compensated lost work. The second significant interaction involves effect modification of the association between working in the construction industry and 6 months or more of lost work by company size. Those who work in the construction industry were more likely (OR 1.24, CI 1.04-1.47) to have 6 months or more of compensated lost work time than those who work in other industries, among those who work for companies with less than 50 full time employees. However, among workers in larger companies, those in the construction industry, compared to other industries, have a greater likelihood of 6 months of lost work (OR 1.63, CI 1.47-1.81). Those who worked for large companies had higher ORs than those who worked for small companies.

Quantile regression was carried out using the same predictor specifications with the eightieth percentile of lost workdays as the dependent variable (approximately 6 months cumulative lost workdays) (Table 4.3). One advantage of quantile regression is that it provides a quantitative estimate of the number of lost work days associated with different variables. The strongest predictor was hospitalization within 28 days of injury. Hospitalized workers had 368 more lost workdays than those not hospitalized within 28 days from injury, holding other predictors constant. The other strong predictors were as follows; workers with 27 or more days between injury and first medical visit had 143 more lost workdays than those who had medical treatment within 27 days, workers with back and neck injury had 120 more lost workdays than those with other injuries (reference category), workers in the construction industry had 93 more lost workdays

than those in other industries (reference category), and workers over 45 years of age had 76 more lost workdays than those under 30 years old.

The Cox proportional hazard model showed that hospitalization within 28 days of injury was the strongest predictor of cumulative compensated lost workdays (disability) (Table 4.4). Workers hospitalized within 28 days were about half as likely to end lost workdays at any given time (hazard ratio 0.55). Compared to workers under 30 years old, workers between 30 and 44 had a hazard ratio of 0.77, and workers over 44 had a hazard ratio of 0.72. Workers with the first medical appointment more than 28 days from injury date, and workers in the construction industry, both had hazard ratios of 0.77. Workers with back and neck injuries were about 80% (hazard ratio 0.82) as likely to return to work at any given time than those with other injuries, holding other predictors constant. Injuries involving contusions, cuts, or scratches predicted the highest likelihood of ending disability at any time, with a hazard ratio of 1.26.

There was considerable agreement between the statistical models. The three models used cumulative compensated lost work time (disability) as the dependent variable, and found the same predictors significant and stable.

Strengths and Limitations

There are several strengths of this study. They include a large population-based data set, long follow-up period, and agreement among the findings generated by different statistical models. The potential for sample bias is reduced by using a large administrative data set, thus avoiding bias associated with voluntary participation. There are also limitations to this study. Several categories of predictors are not available in

this workers' compensation data system. These include workplace factors, including turnover, return-to-work programs, and hazard exposure; worker information such as tenure, and functional status; and psychosocial factors such as job satisfaction, co-worker and supervisor support. Furthermore, self-reported work absences have been shown to be two times the length of work absences represented in workers' compensation administrative data systems for back injuries.¹⁰ Until administrative systems routinely collect self-reported information, the under representation of work disability needs to be considered when interpreting results. Some misclassification is present in administrative data systems. Due to the long pre-clinical phase of some disorders, determining injury date is difficult and thus calculation of lapsed time from injury to treatment is likely to have some error. For example, in an evaluation of occupational carpal tunnel syndrome (CTS) incidence rates in Washington, 82% of incident CTS cases were documented by physician diagnosis in the medical records. However, this over-counting was determined to be non-differential misclassification that would result in a greater likelihood of null findings (less likelihood of finding statistically significant associations between independent and dependent variables).³⁰

Discussion

This study presented evidence regarding predictors of long-term disability in a workers' compensation population. Several factors lend support to these findings. The same factors were strong predictors across logistic, quantile, and Cox regression models for predicting cumulative lost workdays. In general, the results are consistent with the analysis conducted by Cheadle et al. using earlier data (1987 to 1989) from the

Washington State workers' compensation population.⁷ The strongest predictors from each model were the same but had different rankings. These are, hospitalization, age, interval between injury and treatment, construction industry, logging occupation, gender, and upper extremity non-traumatic musculoskeletal disorders. These factors can be used to identify cases that are more likely to lead to long-term disability and therefore, cases, which warrant a special focus for intervention. Using coefficients from the logistic model, an injured worker in the riskiest category for five of the strong predictors, (a female over 44 years old who was hospitalized within 28 days of injury with a back or neck injury and who worked in the construction industry with the referent category values for the other covariates) would be 42 times (OR 41.86, CI 35.01-50.04) more likely to have 6 months or more of lost work than a worker with all referent category values (Table 4.2). One potential application of the results from this study is that they may contribute to the development of instruments that can identify high-risk cases early in the course of disability. Once identified, clinicians could develop medical management, rehabilitation plans, or return to work goals, aimed at reducing disability.³¹

The strongest predictor of long-term disability was severity of injury as measured by hospitalization within 28 days of the injury. This highlights the importance of primary prevention in reducing the incidence and severity of workplace injury. Surveillance and screening programs to detect high-risk groups, when followed by workplace interventions, are successful in reducing disability time. This need for stronger work place interventions is shown by a study of low back and upper extremity

MSD claims in New Hampshire that reported almost 40% of workers suffered a re-injury after their initial return to work.³² Recommendations concerning job modification from physicians was found to result in a higher likelihood of employer interventions.¹⁴ To support this type of physician involvement, economic incentives need to be changed so providers are compensated adequately for time spent on prevention activities and are evaluated for prevention performance.³³

This study found that workers with more than 27 days from injury to first medical treatment were less likely to end disability at any given time (hazard ratio 0.77). At the 80th percentile, workers incurred 143 more days of disability than those receiving treatment within 27 days of injury. Other researchers have found this association between delay in treatment and disability among people with back pain.^{24 25} The long time interval between injury to first medical treatment delays interventions to reduce disability such as medical intervention, identification of cases more likely to have long-term disability, case management through DLI, and the involvement of the employer in resolving the case. Efforts by the insurance system, the employer, and medical service provider to shorten this delay may trigger earlier interventions. With timely referral, improved physician training, and improved care coordination, the incidence and duration of disability can be reduced.^{34,35} Specific actions include, starting planning for return-to-work earlier in the course of disability, setting and monitoring realistic expectations and progress markers by medical service providers, employers, and workers. Return to work programs, medical management, surveillance programs, and prevention of re-injury are essential for reducing disability.³⁶ In jobs with

high levels of exposure, incidence rate reduction can be high.^{37,38,39} As part of medical management, specific job restrictions during recovery are critical for successful return to work.⁴⁰ Multifaceted programs combining interaction with co-workers and workplace job modification to reduce physical demands during recovery have shown good success. Disability reduction of 30-50%, with light duty and medical management, has been observed.¹² Job modification can be facilitated through ergonomic programs that have a significant influence on the severity and incidence of musculoskeletal disorders. Methods for workload management include rotation of workers between tasks with varying levels of exposure (to provide needed breaks for tissue involved in the task), designing tasks to minimize exposure and teaching these techniques to workers, and reintroducing workers to hazardous jobs gradually following work absence, with a maximum of two continuous hours on a task.⁴¹ MSDs resulting in lost work are one-third as common when ergonomics interventions are implemented.⁴² For example, reduction of hazardous exposures through ergonomic programs is critical to successful return to work, in light of the 40% rate of re-injury.³² In high exposure jobs, incidence reduction of 50-90% has been observed with implementation of ergonomics programs.^{37, 38, 39}

Workers delay filing workers' compensation claims for many reasons but efforts to shorten this delay are warranted.⁴³ Many workers delay filing due to concerns about employer reprisals, losing their job, or compromising rewards offered through employer safety incentive systems.^{44,45} Employers may use this information to encourage workers to file claims sooner after injury and assure workers filing will not result in reprisals.

Educating workers to recognize important symptoms of MSDs related to cumulative trauma may improve detection of these disorders in their earlier stages, when interventions are more effective in preventing long-term disability.

As individuals age, more severe disability is associated with similar injuries, and common degenerative processes reduce musculoskeletal function. Age has been demonstrated to be a predictor of MSD disability in many studies, but not all have found a positive association.^{7,22,23} This study found workers over 45 years in age were twice (OR 2.0) as likely to have 6 months or more of lost workdays compared to workers younger than 33 years.

Gender of the worker was a significant predictor of ending disability with women less likely to do so at any time (hazard ratio 0.84). This is similar to findings of Cheadle (hazard ratio 0.85) using Washington State data.⁷ However others have not found this association.^{46 24 30} In the present study, the effect of acute back and neck injury on disability was modified by gender, with males having greater likelihood of disability (OR 1.9) while the likelihood of disability for females with acute back and neck injury compared to other injuries was less (OR 1.6). Some of this difference may be explained by gender segregation in the workplace where certain types of work are more common to women.⁴⁷ Also, differences in healthcare seeking behavior may contribute to the reporting of disability.

The Washington State retrospective rating program predicted higher probability of ending disability (hazard ratio 1.1). The magnitude of effect was small in the present study. An earlier study that used Washington data found no statistical difference with

participation at injury date (hazard ratio 1.0) but did find statistical significance when the company participated in the retrospective program for all years of follow-up (hazard ratio 1.1).⁷ The size of the financial investment in the retrospective program should be reviewed in light of the small effect size it has in relation to the reduction in disability that may be gained through other approaches.

There is a recognized need within the field of occupational medicine for better information regarding the predictors of long-term disability partly because a small percentage of disability claims account for a majority of costs. Focusing intervention (targeting resources) on cases associated with long-term disability may reduce disability and cost. This study has identified several factors that predict long-term disability that may be useful to those who allocate resources and guide policy.

Physician input to patients and employers regarding job modification could significantly improve a worker's chances of remaining in the workforce, given the effect of selected factors to predict long-term disability, as outlined above. Education of medical providers, workers and employers concerning the importance of early injury intervention (access) could result in less long-term disability – a benefit to all. Finally, findings from this study highlight the importance of primary and secondary prevention targeted at selected industries (e.g. construction) and occupations (e.g. logging), that put workers at higher risk for long-term disability.

Table 4.1 Predictor Descriptions

Predictors	% of Workers	Mean Cumulative Lost Workdays
Age		
<30	27.4	102.5
30-44	46.9	182.5
45 up	25.7	188.4
Gender		
Male	70.5	156.9
Female	29.5	174.6
Marital		
Married	48.5	178.0
Single	51.5	147.1
Dependents		
None	60.7	153.7
>0	39.3	175.0
Injury		
Other	16.5	156.3
Upper extremity NTMSD	17.1	168.7
Neck/Back NTMSD	22.8	173.6
Neck/Back	9.7	218.4
Fracture	10.0	159.1
Contusion/Cut/Scratch	13.9	101.3
Sprain/Dislocation	9.9	167.0
Hospitalized within 28 days		
No	96.2	155.5
Yes	3.8	325.8
Days Injury to Med Visit		
<28 days	93.5	156.2
>27 days	6.5	246.0
Company Size		
<50	52.1	80.2
=>50	47.8	42.3

Table 4.1 Continued

Predictors	% of Workers	Mean Cumulative Lost Workdays
Retrospective Rating		
No	58.4	170.6
Yes	41.6	150.1
Industry		
Other	6.6	138.9
Agriculture, Forestry, Fishing	6.0	175.2
Construction	20.1	209.7
Manufacturing	14.3	151.3
Transportation, Utility	7.0	150.2
Wholesale	6.9	144.6
Retail	15.8	136.7
Services	23.3	156.6
Unemployment Rate		
<3.3	35.8	148.0
3.3-4.8	27.5	159.5
>4.8	36.6	177.7
Occupation		
Other, not reported	9.8	160.0
Managerial, Professional	5.8	173.1
Technical, Sales, Admin support	7.9	156.5
Service	15.1	142.2
Farming, Forestry, Fishing	5.2	172.3
Craft, Repair	22.8	188.4
Operators, Fabricators, Laborers	31.8	148.3
Logging	1.5	217.0
Claim Year *		
1997	31.4	-
1998	35.1	-
1999	33.4	-

* Censoring effects disability duration.

Table 4.2 Logistic Regression Results

Predictors	Adjusted OR	95%CI	Stability
Age <30 ⁺			
30-44	1.78	1.69, 1.88	*
45 up	1.99	1.87, 2.11	*
Female	1.56	1.48, 1.64	*
Married ⁺			
Single	0.55	0.91, 0.99	-
Dependents, >0	1.17	1.12, 1.22	*
Injury, Other ⁺			
Upper extremity NTMSD	1.35	1.26, 1.44	*
Neck/Back NTMSD	1.42	1.33, 1.52	*
Neck/Back	1.80	1.67, 1.94	*
Fracture	0.86	0.79, 0.94	-
Contusion/Cut/Scratch	0.62	0.58, 0.68	*
Sprain/Dislocation	1.31	1.21, 1.42	-
Hospitalized in 28 days, Yes	4.26	3.90, 4.66	*
Injury to Med Visit <28 days ⁺			
>27 days	1.75	1.64, 1.88	*
Company Size <50 ⁺			
>49	0.84	0.81, 0.88	*
Retrospective Rating, Yes	0.86	0.82, 0.90	*
Industry, Other ⁺			
Farming, Forestry, Fishing	1.31	1.14, 1.51	-
Construction	1.76	1.60, 1.94	*
Manufacturing	1.21	1.10, 1.34	-
Transportation, Utility	1.19	1.06, 1.34	-
Wholesale	1.08	0.97, 1.21	-
Retail	1.13	1.03, 1.24	-
Services	1.17	1.07, 1.28	-
Unemployment Rate <3.3 ⁺			
3.3-4.8	1.08	1.03, 1.14	-
>4.8	1.15	1.10, 1.21	-
Occupation, Other ⁺			
Managerial, Professional	0.94	0.85, 1.04	-
Tech., Sales, Admin. Support	0.91	0.82, 1.00	-
Service	0.84	0.78, 0.92	-
Farming, Forestry, Fishing	1.09	0.95, 1.25	-
Craft, Repair	1.01	0.93, 1.09	-
Operator, Fabricator, Laborer	0.99	0.93, 1.07	-
Logging	1.59	1.34, 1.87	*

⁺ Indicates reference category * Stability assessed by modeling each claim year separately. Factor was statistically significant, had the same sign, and magnitude was within 25% of the average coefficient for all 3 claim years.

Table 4.3 Quantile regression results

Predictors	Coefficient	95% CI		Stability
Age <30 ⁺	1.00			
30-44	61.06	54.79,	67.33	*
45 up	76.54	69.18,	83.90	*
Female	58.51	51.83,	65.19	*
Married ⁺	1.00			
Single	-3.89	-9.42,	1.65	-
Dependents, >0	24.40	18.67,	30.12	*
Injury, Other ⁺	1.00			
Upper extremity NTMSD	45.39	36.53,	54.25	*
Neck/Back NTMSD	51.90	43.54,	60.25	-
Neck/Back	120.39	110.01,	130.77	*
Fracture	-8.97	-19.26,	1.31	-
Contusion/Cut/Scratch	-28.11	-37.44,	-18.78	*
Sprain/Dislocation	34.87	24.58,	45.15	-
Hospitalized in 28 days, No ⁺	1.00			
Yes	368.40	354.85,	381.95	*
Injury to Med Visit <28 days ⁺	1.00			
>27 days	143.48	132.98,	153.97	*
Company Size <50 ⁺	1.00			
>49	-18.86	-24.58,	-13.13	*
Retrospective Rating, Yes	-19.78	-25.32,	-14.31	*
Industry, Other ⁺	1.00			
Farming, Forestry, Fishing	35.31	17.45,	53.16	-
Construction	93.45	80.87,	106.02	*
Manufacturing	22.47	9.73,	35.21	-
Transportation, Utility	26.86	12.47,	41.25	-
Wholesale	12.88	-1.38,	27.13	-
Retail	20.09	8.02,	32.15	-
Services	20.04	8.67,	31.42	-
Unemployment Rate <3.3 ⁺	1.00			
3.3-4.8	6.44	-0.09,	12.97	-
>4.8	18.73	12.56,	24.89	-
Occupation, Other ⁺	1.00			
Managerial, Professional	-1.02	-14.71,	12.66	-
Tech., Sales, Admin. Support	-15.31	-27.90,	-2.72	-
Service	-11.29	-22.42,	-0.17	-
Farming, Forestry, Fishing	12.69	-4.79,	30.16	-
Craft, Repair	0.67	-9.49,	10.84	-
Operator, Fabricator, Laborer	-1.42	-10.85,	8.02	-
Logging	76.46	53.31,	99.61	*

Table 4.4 Cox regression results

Predictors	Hazard Ratio	95% CI	Stability
Age <30 ⁺	1.00		
30-44	0.77	0.76, 0.78	*
45 up	0.72	0.70, 0.74	*
Female	0.84	0.82, 0.85	*
Married ⁺	1.00		
Single	1.04	1.02, 1.05	-
Dependents, >0	0.93	0.91, 0.94	*
Injury, Other ⁺	1.00		
Upper extremity NTMSD	0.89	0.87, 0.91	*
Neck/Back NTMSD	0.94	0.92, 0.97	-
Neck/Back	0.82	0.79, 0.84	*
Fracture	1.00	0.97, 1.03	-
Contusion/Cut/Scratch	1.26	1.23, 1.30	*
Sprain/Dislocation	0.92	0.90, 0.95	-
Hospitalized in 28 days, No ⁺	1.00		
Yes	0.55	0.52, 0.57	*
Injury to Med Visit <28 days ⁺	1.00		
>27 days	0.77	0.74, 0.79	*
Company Size <50 ⁺	1.00		
>49	1.07	1.05, 1.09	*
Retrospective Rating, Yes	1.07	1.06, 1.09	*
Industry, Other ⁺	1.00		
Farming, Forestry, Fishing	0.89	0.84, 0.93	-
Construction	0.77	0.74, 0.80	*
Manufacturing	0.93	0.90, 0.97	-
Transportation, Utility	0.92	0.88, 0.96	-
Wholesale	0.96	0.92, 1.00	-
Retail	0.98	0.95, 1.01	-
Services	0.94	0.91, 0.97	-
Unemployment Rate <3.3 ⁺	1.00		
3.3-4.8	0.97	0.95, 0.99	-
>4.8	0.93	0.91, 0.95	-
Occupation, Other ⁺	1.00		
Managerial, Professional	1.01	0.97, 1.05	-
Tech., Sales, Admin. Support	1.04	1.01, 1.08	-
Service	1.08	1.04, 1.11	-
Farming, Forestry, Fishing	0.97	0.92, 1.02	-
Craft, Repair	0.99	0.96, 1.02	-
Operator, Fabricator, Laborer	1.01	0.98, 1.03	-
Logging	0.82	0.77, 0.88	*

Kaplan-Meier survival estimate

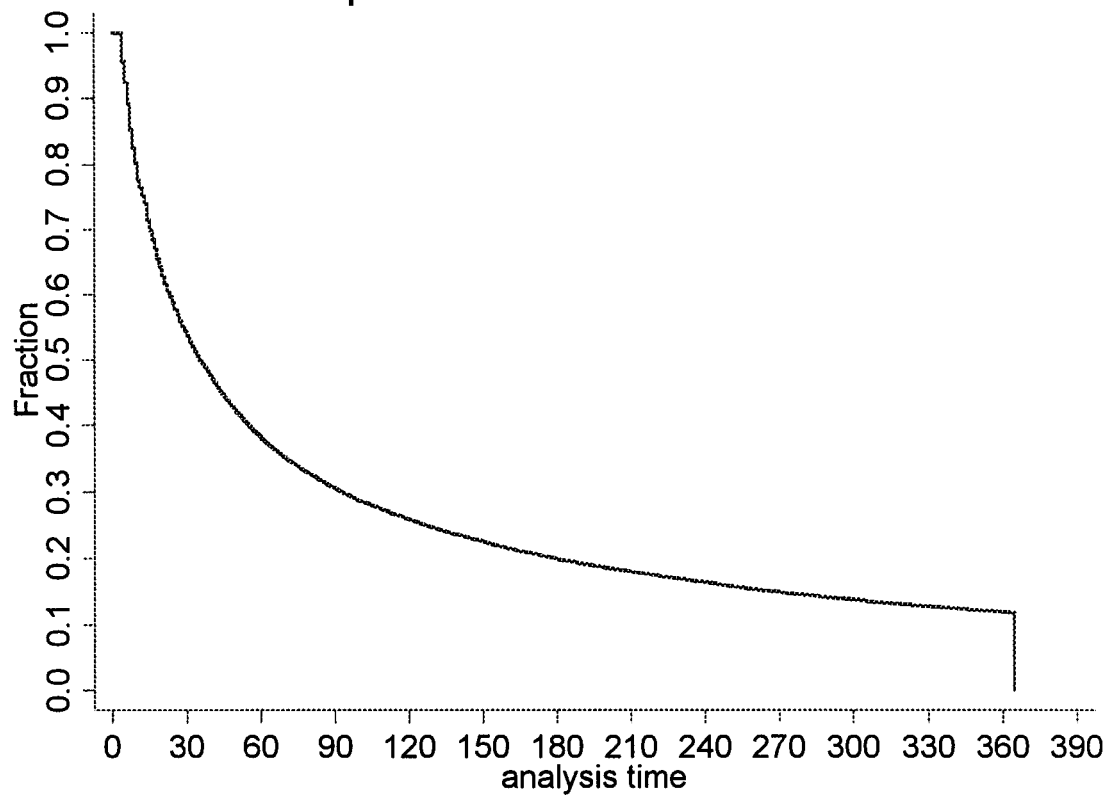


Figure 4.1. Kaplan-Meier survival curve of fraction of workers receiving disability payments by the number of days of disability compensation. Not adjusted for covariates. Compensated lost workdays truncated at 365 days.

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Chapter 5: Conclusions.

With disability affecting 10% of the workforce at any time, improving methods to reduce this burden are justified. This dissertation has addressed the broad topic of work-related disability in two ways. First, I examined the validation and accuracy of a functional disability instrument for use in workplace screening for primary prevention (chapters 2 and 3). This work provides the first published investigation of a functional disability instrument for use as a screening tool in a healthy working population. Second, I explored factors that predict long-term disability that are routinely collected in a workers' compensation system (chapter 4).

Assessing Functional Disability with the QuickDASH

Musculoskeletal disorders (MSDs) are the most common workplace injury today and comprise a high percentage of workers' compensation claims. These disorders frequently result in long periods of disability. But diagnosis of MSDs is difficult and clinical treatment has limited effectiveness making surveillance and prevention critical. Researchers and federal agencies have noted the need to improve detection and evaluation of work related MSDs. Once these injuries have been identified, intervention can reduce the disability burden. Early detection of upper extremity MSD is key to successful treatment and to minimize incidence and severity.^{1,2,3,4} However, clinical methods may not be sufficiently sensitive, reliable, or inclusive to facilitate early detection. Even when there is diminished functional status, some MSDs are not readily definable as anatomically specific disorders, and imaging studies may not provide a clear definition of the problem.⁵ For many MSDs there is no objective way to make a

diagnosis or measure severity.⁶ Thus, clinical diagnosis as an outcome measure for workplace intervention and program evaluation may not be as useful as disability measures.

Functional status includes factors not represented in symptom status, such as personality, motivation, social and economic supports. Thus functional status instruments may be more sensitive and accurate for identification of those with or likely to develop MSDs. Some functional disability instruments exist but need to be validated in working populations to assess their accuracy and improve interpretation.⁷ Additionally, there is little research concerning the utility of functional status instruments for accurately classifying the working population as normal and abnormal MSD status.

In chapter 2, the construct validity of a newly developed instrument, the QuickDASH, was examined. Hypotheses were presented concerning the expected relationships between QuickDASH scores and responses to other concepts of functional disability in the workplace such as, clinical diagnosis, symptom severity, and the SF-12 Health Survey.⁸ ⁹Construct validity is related to the population or specific application of the test, and the spectrum of illness severity in that population. Therefore, construct validity should be evaluated in a population similar to the population in which the instrument will be used.¹⁰ This study examined the validity of the QuickDASH in a working population with a wide range of upper extremity MSD severity in order to investigate its validity for use as a screening instrument.

The findings of this study support the validity of the QuickDASH as an instrument to assess upper extremity MSD disability in this working population. Specifically, workers with at least one upper extremity MSD clinical diagnosis had significantly higher QuickDASH scores than those without a diagnosis. Workers with severe or very severe symptoms had significantly higher QuickDASH scores than those without. Further, there was a statistically significant trend of increasing QuickDASH scores with increasing levels of upper extremity symptom severity. Similar findings were reported for the (31-item) DASH among patients with ulnocarpal impingement.¹¹

In this study, the QuickDASH and the SF-12 physical component appear to measure different phenomenon as indicated by a correlation of -0.03 . Other researchers found a correlation of 0.74 between the DASH and the SF-12 physical component score in surgical patients.¹² The correlation with the DASH may reflect the patient population in that study in contrast to the full-time worker (healthier) population in the present study. Further, SF-12 physical component scores did not distinguish between workers with or without a MSD diagnosis in the present study. Consistent with these findings, the SF-12 physical component scores were not different for workers without symptoms or with mild or moderate symptoms as compared to workers with severe or very severe symptoms. The QuickDASH was not developed to measure mental function and divergent construct validity was confirmed by the lack of correlation between the QuickDASH scores and the SF-12 mental component scores. The SF-12 health survey was developed to measure global health status, which contrasts with the QuickDASH

that was developed to assess disability of the upper extremity. Replication in other worker populations is needed before conclusions can be drawn from these findings.

The QuickDASH does not differentiate well among workers with low levels of disability. However, it does distinguish between those reporting none or mild symptom severity, which may be adequate for workplace screening and surveillance applications. This suggests that nonzero scores may be an indicator that closer scrutiny of persons and jobs is warranted.

The QuickDASH had good internal consistency in this population of workers and the cross-sectional precision of the baseline scores provided sufficiently narrow confidence interval for group screening. Caution should be used when interpreting these scores on an individual worker basis. Chapter 3 examined the accuracy of the QuickDASH as a screening tool for surveillance.

The QuickDASH performed well in detecting MSD problems in this working population. Baseline sensitivity for musculoskeletal disorder diagnosis was 73% with specificity of 56%. For symptom severity sensitivity was 96% and specificity was 53%. The positive predictive value of the QuickDASH to identify workers with MSD diagnosis at baseline was 50% and the negative predictive value was 78%.

This validation and demonstration of the accuracy of the QuickDASH provides preliminary support for its use in epidemiological studies, program evaluation, and as a screening tool for workplace surveillance. Once identified through screening programs, the incidence and severity of work related MSDs may be reduced through appropriate intervention.^{13,14, 15}

Appropriate use of the QuickDASH as a screening tool will be better understood if research considers the association of musculoskeletal hazard checklists and postural discomfort instruments with important markers of MSD screening programs, like upper extremity MSD diagnosis, lost workdays, obtaining medical care, change of job, light or restricted work, and symptoms due to musculoskeletal problems. This study contributes to the literature concerning detection of work-related MSDs. The application of a functional disability instrument (the QuickDASH) for use as a screening tool in a healthy working population is unique. This study's finding that the QuickDASH is valid and sufficiently accurate for screening supports corroboration in future studies. Understanding of the association between functional disability instruments and markers of MSD screening program success can be furthered by the study of other worker populations, and by the inclusion of workers without musculoskeletal problems. An instrument's responsiveness to change is important for its use in surveillance programs. However, the ability of the QuickDASH to measure change in a workers condition has not been evaluated in the literature.

Predictors of Long-term Disability

The burden of workplace injury and illness is significant. Workplace injuries resulted in costs of \$129 billion dollars in 1992 including 2.7 million disabling work injuries.¹⁶ Criteria for diagnosis are often ambiguous for the most common disabling injuries, back and MSDs. These injuries often lack clear pathological processes or physiological mechanisms.¹⁷ More often than not symptomatic MSD injuries are not verified by x-rays or other positive imaging findings.¹³ Early detection of disorders is

often difficult because of insensitive clinical methods and crude resolution in diagnostic tests.¹⁸ Back pain conditions lack specific diagnosis in 85% of the cases.

Much of the cost for workplace injury and its resulting disability is externalized. Those responsible for the injuries and their prevention do not bear the true cost. Workers' compensation systems cover 45% of direct costs, and 27% of all costs of occupational injuries and illnesses. Private health insurance covers 18%, public funds 24%, and workers pick up 13% of the direct costs.¹⁶ There are also consequences for workers, families, and society which are not reflected in these expenditures of medical costs, lost time at work, insurance administration, fringe benefits, and worker replacement and retraining.^{19,20} These include diminished future work activity, pain, interrupted careers, disruption in family relationships, reduction in household production, reduced community involvement, and diminished quality of life.²¹ There is also the lost opportunity to invest these resources for productive uses.

Secondary prevention, the intervention in a claim before long-term disability is established at 3 to 6 months, does have demonstrated effectiveness. Secondary prevention has the advantage of focusing available resources on those cases with the greatest risk of long-term disability. A small percentage of long-term disability cases consume a high percentage of expenditures. This study contributes to the existing literature regarding the identification of those cases more likely to result in long-term disability by exploring the application of existing workers' compensation administrative data systems for this task. This data has the advantage of being available at no extra cost, available soon after a claim is filed, and constantly being updated. The strongest

predictors in this study were days to hospitalization, age, interval between injury and treatment, construction industry, logging occupation, gender, back injury, and upper extremity non-traumatic musculoskeletal disorders.

This study contributes to the understanding of factors that predict long-term disability. This understanding can assist in the development of instruments that recognize high-risk cases early in the course of disability. Once high-risk claims are identified clinicians can develop medical management, rehabilitation plans, and return to work goals, aimed at controlling disability.²² Disability reduction has been achieved through workplace interventions, changes in health care delivery, and workers' compensation policies. Reductions have been achieved by early medical management, improved physician training, and a focus on care coordination.^{17,23} Important components of these interventions are an active role for the insurance case manager and ergonomic accommodation in the workplace along with common goals determined by all stakeholders including employers, workers, medical service provider and insurer.²⁴

This study highlights the importance of severity of injury in predicting long-term disability. Workers hospitalized within 28 days of injury were 4 times more likely to have 6 or more months of disability than those hospitalized later or not at all. Efforts targeted to prevention of these severe workplace injuries is indicated. This finding contributes to the previous identification of this crucial disability predictor and emphasizes the need for reducing injury severity. Almost 40% of workers with low back and upper extremity MSD claims suffered a re-injury after their initial return to work²⁵, and 60% are not able to continue to work following their initial return to

work.²⁶ Surveillance programs and prevention of re-injury are essential for reducing disability. Analysis of surveillance data to identify injury trends and spot sentinel events needs to become common practice for health and safety professionals and insurers. The present study indicates that this is especially true in construction companies and logging operations. An important contribution of this study is the finding that workers in larger (50 or more full time employees) construction companies have longer disability than smaller ones. Health and safety program practices of these large construction companies may need to include renewed focus on detecting trends and sentinel events to guide prevention of these severe injuries. Another approach for protecting workers after they return to work is strengthened physician involvement. Recommendations concerning job modification from physicians was found to produce a higher likelihood of employer interventions.²⁷ Economic incentives need to be improved to adequately compensate health care providers for time spent on prevention activities and changes in performance evaluation could include length of disability.²⁸

One contribution of this study is the confirmatory finding that delayed medical treatment is associated with longer disability. In this study, workers with more than 27 days from injury to first medical treatment incurred 143 more days of disability at the 80th percentile than those receiving treatment within 27 days of injury. Other researchers have found this association between delay in treatment and disability among people with back pain.^{29 30} The treatment lag delays medical intervention, the identification of cases more likely to have long-term disability, case management through DLI, and the involvement of the employer in resolving the case. With timely

referral, improved physician training, and improved care coordination, the incidence and duration of disability can be reduced.³¹ Actions by insurance companies, employers, and medical service providers can reduce this treatment lag. Multifaceted programs combining interaction with co-workers and workplace job modification to reduce physical demands during recovery have shown good success. Disability reduction of 30-50%, with light duty and medical management, has been observed.³²

Employers can use the predictive ability of delayed treatment to encourage workers to file claims sooner after injury. Workers delay filing workers' compensation claims for many reasons but efforts to shorten delays are warranted.³³ Many workers delay filing due to concerns about employer reprisals, losing their job, or compromising rewards offered through employer safety incentive systems.³⁴ Assuring workers that filing compensation claims will not result in reprisals and educating them to recognize early MSDs related symptoms can shorten the treatment lag and hopefully reduce long-term disability.³⁵

Work is needed to improve understanding of the factors that contribute to long-term disability. Research incorporating a wider set of predictive factors will likely explain more of the variation in long-term disability. Factors not included in the present study but worth considering are workplace factors including turnover, return-to-work programs, and hazard exposure; worker information such as tenure, and functional status; psychosocial factors such as job satisfaction, co-worker and supervisor support. Other dependent variables like self-reported work absences can provide a different context for representing the disability burden. Self-reported work absences have been

shown to be twice the length of those represented in workers' compensation administrative data systems for back injuries.³⁶

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