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Development and Validation of a Predictive Model of Return-to-Work Outcomes of Injured Employees in Minnesota

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DEVELOPMENT AND VALIDATION OF A PREDICTIVE MODEL OF RETURN-TO-WORK OUTCOMES OF INJURED EMPLOYEES IN MINNESOTA

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Health Related Sciences – Rehabilitation Leadership at Virginia Commonwealth University.

by

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Abstract

DEVELOPMENT AND VALIDATION OF A PREDICTIVE MODEL OF RETURN-TO-WORK OUTCOMES OF INJURED EMPLOYEES IN MINNESOTA

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In Minnesota's workers' compensation system, injured employees at risk for sustaining permanent disability may be eligible for receipt of vocational rehabilitation (VR) services if they are determined to be capable of benefitting from such services. VR services can be a valuable resource to injured employees who need assistance minimizing their work disability and maximizing their residual wage-earning capacity. However, for VR services to be effective at a system level, it is necessary to precisely and accurately identify an injured employee's rehabilitation potential. Failure to do so is likely to result in the misallocation of a scarce and costly resource.

Given recent trends in Minnesota's workers' compensation system (e.g., higher VR service costs and lower RTW rates among injured employees with indemnity claims), this study was conducted with the purpose of developing and validating an objective, evidence-based

method of predicting the RTW status as of claim closure of injured Minnesota employees who sustained permanent impairment and received VR services. To accomplish this purpose, a closed-claim, retrospective design was implemented. Data for this cross-sectional study was obtained from the Minnesota administrative claims database. There were 15,372 claims that met all eligibility criteria. With guidance from the biopsychosocial disablement models developed by Nagi and the World Health Organization, 15 discrete predictor variables that represented medical, individual, and workplace factors were selected for study inclusion.

Descriptive and predictive analyses were used to assess the relationship between this study's RTW outcome and its set of RTW predictors. Using logistic regression, an optimal RTW model was first developed and then internally validated with a split-dataset approach. The optimal RTW model included four main effects (attorney involvement; severity of permanent impairment; age; job tenure) and three first-order interaction effects (pre-injury average weekly wage X pre-injury industry; attorney involvement X severity of permanent impairment; attorney involvement X job tenure). Though not retained in the optimal RTW model, part of body affected and education also had notable bivariate relationships with the outcome. The optimal RTW model's performance regarding goodness-of-fit and clinical usefulness suggests it may be of value to those assessing rehabilitation potential within Minnesota's workers' compensation system.

Chapter 1: Introduction

Study Background

Workers' compensation is a distinctive aspect of American social insurance due to the lack of a uniform federal system to provide support for injured or ill employees. Unlike other large social insurance programs such as Social Security Disability Insurance or Medicare which are federally operated, each state has its own workers' compensation system. A natural consequence of the lack of federal involvement in the financing and administration of these systems is a lack of standardization in the laws that govern them (and data that is collected within them). This often makes it difficult to compare one system to another. Nevertheless, aggregated data gathered from workers' compensation systems in the United States (U.S.) (including those for each of the fifty states, for the District of Columbia, and for various federal programs) can be helpful in revealing important national realities. For example, though each system is unique, it is clear that work-related injuries and illnesses are a common and costly problem throughout the U.S. In 2011 alone, there were nearly 3.0 million nonfatal workplace injuries and illnesses reported among private industry employers (U.S. Department of Labor, 2012). That same year, employer costs for workers' compensation totaled $77.1 billion (Sengupta, Baldwin, & Reno, 2013, p. 28).[1] Additionally, after factoring in additional costs

[1] Employer costs as defined by the National Academy of Social Insurance (NASI) include employer expenditures in a calendar year for workers' compensation benefits, administrative costs, and/or insurance premiums (specifically premium costs and deductibles for insured employers and benefits paid and administrative costs for self-insured employers).

such as wage and productivity losses, the National Safety Council (2013) estimated that workplace injuries and illnesses cost Americans $188.9 billion in 2011.[2] A significant component of workers' compensation system costs (particularly employer costs) is employee benefits. Total benefits paid to injured or ill employees (hereafter referred to as injured employees for simplicity) amounted to $60.2 billion in 2011 (Sengupta et al., 2013, p. 17). Employee benefits include medical benefits to cover the costs of treatment for a work-related injury and indemnity benefits that compensate an injured employee for lost work time beyond a three- to seven-day waiting period after the incident. In most U.S. workers' compensation systems, vocational rehabilitation (VR) benefits are also available to injured employees who have difficulty returning to, or who are unable to return to, their previous occupation. Employee benefits are thus intended to both help an injured employee recover and return to work (RTW) and, if necessary, to mitigate any wage loss he or she has sustained attributable to a work-related incident. The amount of benefits paid to injured employees varies significantly depending on claim type. In fact, it is a minority of claims that account for a majority of benefit payments. Evidence of this is available from the National Council on Compensation Insurance (NCCI) which tracked 37 state workers' compensation systems between 1998 and 2008. The NCCI found that during this 11-year period medical-only claims (i.e., claims in which only medical benefits are awarded) represented about 76% of all claims filed but only about 7% of total benefits paid (NCCI, 2012). The remaining 24% of workers' compensation claims filed in these 37 states included payment of indemnity benefits for lost work time and constituted about 93% of total benefits paid. Indemnity claims (i.e., claims in which wage-loss benefits are awarded in

[2] Work-related costs as defined by the National Safety Council include wage and productivity losses ($86.7 billion), medical expenses ($52.3 billion), administrative expenses ($34.2 billion), motor vehicle damage ($2.4 billion), employers' uninsured costs ($10.5 billion), and fire loss ($2.8 billion).

addition to medical benefits) are differentiated according to the duration (temporary or permanent) and severity (partial or total) of the injured employee's vocational disability (Sengupta, Reno, Burton, Jr., & Baldwin, 2012, p. 9). Specifically, indemnity claims are most often classified into the following five disability claim types: 1) temporary partial; 2) temporary total; 3) permanent partial; 4) permanent total; 5) death. Data from the NCCI (2012, Exhibits X and XII) reveals that temporary disability claims accounted for 62.6% of 2008 indemnity claims but just 27.8% of total benefits paid in such claims. Permanent partial disability (PPD) claims constituted only 36.8% of 2008 indemnity claims but 61.8% of total benefits paid. Finally, permanent total disability (PTD) and death claims represented 0.7% of 2008 indemnity claims and 10.4% of total benefits paid.

It is apparent from this data that indemnity claims, particularly PPD claims, are the significant cost driver in workers' compensation systems in the U.S. This means that work-related injuries or illnesses that result in permanent disability (as measured by wage loss) are the most costly claims. A key method of controlling these costs in most systems is through the provision of VR benefits. In such systems, VR services (e.g., rehabilitation counseling; job-seeking skills training; job placement) are available to injured employees who are at high risk of sustaining permanent disability (e.g., injured employees unable to return to their previous occupation). The primary purpose of VR service provision is to help control the indemnity benefits paid to injured employees by mitigating their degree of disability. Thus, VR services are ideally mutually beneficial in that they simultaneously minimize employer indemnity costs and maximize employee RTW rates. However, because the provision of VR benefits varies from one system to another (e.g., variations in eligibility criteria), it is difficult to assess the extent to which VR services help accomplish these desired outcomes from a national perspective.

This researcher is fortunate to have been provided access to an administrative claims database containing information about injured employees in Minnesota's workers' compensation system. This claims database is developed and maintained by the Minnesota Department of Labor and Industry and includes extensive information about injured employee claims in Minnesota since 1983. The wealth of medical and non-medical information included in this database makes it especially useful for workers' compensation system evaluation and public policy development. It is noteworthy that claims data from Minnesota reveal that their workers' compensation system shares many traits with other systems throughout the U.S. For example, consistent with aggregated data from all U.S. workers' compensation systems, workplace injuries and illnesses are common and costly occurrences in Minnesota as there were approximately 75.4 thousand work-related incidents reported in the state in 2011 (Zaidman, 2013, p. 6) resulting in a total cost of $1.45 billion (Berry & Zaidman, 2013, p. 6).[3] Also consistent with other U.S. workers' compensation systems is the fact that a majority (67.3%) of employer costs in Minnesota's system in 2011 (Berry & Zaidman, 2013, p. 7) were attributable to employee benefits.[4]

Data from Minnesota's workers' compensation system regarding costs by claim type are also similar to aggregated national data in that a small percentage of claims account for a substantial portion of benefit payments. In fact, medical-only claims comprised 77.5% of all claims filed in Minnesota in 2009 but represented just 8.8% of total benefits paid (Berry & Zaidman, 2013, p. 14). Conversely, claims involving indemnity benefit payments accounted for only 22.5% of all claims filed in Minnesota in 2008 but constituted 91.2% of total benefits paid.

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[3] Total workers' compensation system cost in Minnesota includes employee benefits, insurer expenses, and state administrative costs and is equivalent to employer costs as defined by NASI.

[4] Benefits consist of indemnity benefits, medical benefits, and VR benefits.

Further, it was indemnity claims that resulted in permanent disability (or a fatality) that were especially costly. While temporary disability claims, whether partial or total, represented 67.6% of all of Minnesota's 2009 indemnity claims (and 15.2% of all claims), they accounted for just 23.4% of total benefits paid (i.e., in medical-only and indemnity claims) (Berry & Zaidman, 2013, p. 14). However, PPD claims constituted 31.6% of all of Minnesota's 2009 indemnity claims (and 7.1% of all claims) and 57.3% of total benefits paid. Finally, PTD and death claims represented only 0.9% of all of Minnesota's 2009 indemnity claims (and 0.2% of all claims) but 10.5% of total benefits paid.[5]

The significant expense associated with indemnity claims is further underscored by the average benefit per claim that is awarded to injured employees. In 2009, the average benefit per indemnity claim in Minnesota was $37,700 whereas the average benefit per medical-only claim was $1,062 (Berry & Zaidman, 2013, p. 14). Regarding indemnity claims, the average benefit per claim is particularly high when permanent disability occurs. Specifically, the average benefit per PPD claim was $75,400 and the average benefit per PTD claim was $399,000 in Minnesota in 2009 (compared to an average benefit per temporary disability claim of $14,350). As is the case in most U.S. workers' compensation systems, Minnesota attempts to minimize these indemnity costs through the provision of VR services to injured employees who are qualified to receive this benefit. In Minnesota, a *qualified employee* is one who meets the following criteria as a result of his or her work-related injury or disease: a) permanently precluded or likely to be permanently precluded from engaging in the employee's usual and customary occupation or from engaging in the job held at the time of injury; b) cannot reasonably be expected to return to

[5] Medical-only claims accounted for the other 8.8% of total benefits paid.

suitable gainful employment with the date-of-injury employer;[6] and 3) can reasonably be expected to return to suitable gainful employment through the provision of rehabilitation services, considering the treating physician's opinion of the employee's work ability (Minnesota Rules 2011, part 5220.0100, subpart 22). This definition clearly suggests that injured employees with a PPD are the primary intended beneficiaries of VR services. It is also consistent with the assertion that injured employees with a PPD are "the group of workers most likely to be offered VR services and to benefit from them" (Vercillo, 2008, p. 2).

The ultimate goal of VR in workers' compensation systems is to return the injured employee to suitable gainful employment (Weed & Field, 2001, p. 52). In Minnesota, *suitable gainful employment* refers to "employment which is reasonably attainable and which offers an opportunity to restore the injured employee as soon as possible and as nearly as possible to employment which produces an economic status as close as possible to that which the employee would have enjoyed without disability" (Minnesota Rules 2011, part 5220.0100, subpart 34). The economic benefits of helping an injured employee attain suitable gainful employment following an injury are evident. For the employee, he or she is able to RTW at a wage comparable to his or her pre-injury earnings level. For the employer, insurance premiums are likely to decline. For the insurer, benefit costs are likely to decrease. What are less evident are the non-economic benefits that injured employees often experience following return to a suitable position. Perhaps the best way to describe these benefits is to identify the serious repercussions linked to involuntary job loss. For example, Strully (2009) recently discovered that job loss due to business establishment closure increased the odds of individuals developing a new, stress-related health condition (e.g., stroke; hypertension; heart attack; psychiatric problems) by 83%.

[6] In practice, this criterion is not followed as 71.7% of injured employees who returned to work in 2011 after receipt of VR services did so with their date-of-injury employer (Berry & Zaidman, 2013, p. 27).

Prior research has found job loss to be associated with feelings of isolation, failure, and rejection, increased anxiety and depression, lowered confidence and self-esteem, and stress-related somatic complaints (DeFrank & Ivancevich, 1986; Eby & Buch, 1994; Kelvin & Jarrett, 1985). Job loss has also been connected to an increased likelihood of marital dissolution (Doiron & Mendolia, 2011) and smoking relapse (Falba, Teng, Sindelar, & Gallo, 2005). Furthermore, job loss that occurs due to an injury resulting in permanent impairment may tend to produce even more adverse effects than job loss that occurs for other reasons (e.g., plant closing; plant layoff). While VR services may not cure all ills associated with involuntary job loss, the pervasive threat of these undesirable consequences makes clear that the successful return of an injured employee to suitable gainful employment is a goal worth pursuing.

Statement of Problem

Though access to VR services is an important benefit to injured employees who must make a work adjustment as a result of their injury, completing a VR plan only to remain unemployed is an empty benefit (California Workers' Compensation Institute, 1989, p. 6). In addition, providing VR services to injured employees who are either capable of returning to work without assistance or who are incapable of returning to work even with assistance is a misallocation of a scarce and costly resource. Therefore, it is essential that disability support programs (e.g., state workers' compensation systems; Social Security Disability Insurance program) offering VR services to injured employees have the ability to correctly identify which employees are qualified for such services (i.e., those who need and will benefit from VR services). Having this ability means having a method of accurately predicting the RTW potential (or a proxy measure such as RTW outcome), and thus the rehabilitation potential, of injured employees. Attempting to develop and/or validate accurate methods of predicting rehabilitation outcomes (e.g., RTW status of an injured employee as of claim closure) has long been a fundamental theme within VR literature (e.g., Ash & Goldstein, 1995; Beck, 1989; Blackwell, Leierer, Haupt, & Kampitsis, 2003; Bolton, 1972; Gardner, 1991; Growick & McMahon, 1983; Gumerman, 1998; Hester, Decelles, & Gaddis, 1986; Hall, 1994; Lam, Bose, & Geist, 1989; Magrega, Spencer, & McDaniel, 1993; Olsheski, 1991; Talley, 1988; Tate, 1992; Tooson, 2003; Vander Kolk & Vander Kolk, 1990; Vercillo, 2008; Wong, 1987; Wong, Gay, & Wainwright, 1987). In fact, Bolton (1979) contended that "it can reasonably be argued that the central professional activity in the provision of rehabilitation services is prediction" (p. 134).

Given the inevitable uncertainty in making judgments about the extent of injured employees' vocational disability, rehabilitation professionals must use the best available data to make predictions about injured employees' RTW outcomes. When making often difficult judgments about human and organizational behavior, a technique for combining data is necessary. The two types of data-combination procedures that have received much attention in the psychological and medical (including rehabilitation) literatures are *clinical judgment* and *mechanical prediction* (Grove, Zald, Lebow, Snitz, & Nelson, 2000, p. 19). Clinical judgment (e.g., expert opinion) refers to making decisions based on the use of informal, subjective methods to combine data. Conversely, mechanical prediction (e.g., regression analysis) refers to making decisions based on the "straightforward application of an equation or table to the data" (Meehl, 1954, p. 15). In terms of process, the distinguishing characteristic between these two mutually exclusive data-combination procedures is that the application of an already developed mechanical prediction method requires no expert judgment (Grove et al., 2000, p. 19). Meanwhile, in terms of outcome, the use of mechanical prediction guarantees complete consistency in decision-making whereas the use of clinical judgment does not. Furthermore, research comparing these two data-combination procedures has found that mechanical prediction techniques are typically as or more accurate than clinical judgment methods at predicting human behaviors (Grove et al., 2000; Meehl, 1959; Sawyer, 1966).

The existing method of determining which injured employees are qualified for VR benefits in Minnesota's workers' compensation system is a clinical judgment procedure. VR benefit eligibility determinations are based on the results of a *rehabilitation consultation* that is typically performed at the request of the employee, employer, and/or Department of Labor and Industry (DLI) commissioner and is conducted by a *qualified rehabilitation consultant*. Such a consultant is "professionally trained and experienced and is registered by the commissioner to provide rehabilitation consultations and to develop and implement an appropriate plan of *rehabilitation services* for an employee entitled to rehabilitation benefits (Minnesota Rules 2011, part 5220.0100, subpart 23). The process surrounding a rehabilitation consultation and the ultimate decision of whether an injured employee is qualified for VR benefits includes several chronological components. Prior to a rehabilitation consultation, an insurer has the right to request a waiver of rehabilitation services. If no such request is made, or when such a request is denied by the commissioner, the qualified rehabilitation consultant who is assigned to an injured employee's case is provided a copy of his or her vocationally relevant records (e.g., first report of injury; disability status report; current treating physician's work ability report). During a rehabilitation consultation, the assigned qualified rehabilitation consultant meets with the injured employee and "gathers information which will permit a determination of the employee's eligibility for rehabilitation" (Minnesota Rules 2011, part 5220.0130, subpart 3, item B). Finally, after a rehabilitation consultation, the assigned qualified rehabilitation consultant prepares a report in which he or she explains the basis for his or her "determination of whether or not the employee is a qualified employee for rehabilitation services" (Minnesota Rules 2011, part 5220.0130, subpart 3, item C). At this point, the employee and the insurer have the right to object to the qualified rehabilitation consultant's determination. In such instances, the commissioner assists in resolving the dispute about the injured employee's entitlement to VR services.

Though this current method of VR benefit eligibility determination in Minnesota's workers' compensation system allows for decisions to be made on case-specific information, it is an inherently subjective process. Consequently, because the method relies on the clinical judgment of rehabilitation professionals, the consistency of decision-making based on this data-combination procedure cannot be guaranteed. The uncertainty in the reliability of the eligibility determinations that are made following rehabilitation consultations becomes more concerning when considering several recent trends related to the provision of VR services in Minnesota's workers' compensation system (Berry & Zaidman, 2012, Chapter 4). First, the VR participation rate (i.e., percentage of paid indemnity claims with a VR plan filed) rose from 15.3% to 23.8% in 2011. Second, adjusting for wage growth, the mean VR service cost per participant increased from $7,220 in 1998 to $8,830 in 2011.[7] Third, over this same period (i.e., 1998 to 2011), the percentage of VR participants with a job reported at [rehabilitation] plan closure fell from 71.5% to 54.5%. Therefore, as higher percentages of injured employees with indemnity claims were determined to be qualified for and subsequently provided VR benefits, service costs went up and RTW rates went down.

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[7] These average service cost per participant figures have been adjusted for wage growth according to the annual change in Minnesota's statewide average weekly wage and both are presented in 2011 dollars.

These troubling trends are of even greater concern when considering the ambiguous reliability of the clinical judgment method that is currently used to determine VR benefit eligibility in Minnesota's workers' compensation system. The simultaneous presence of these trends and the use of a subjective eligibility determination method suggest that an attempt to develop and validate a mechanical prediction procedure to assist in this selection process would be a worthy endeavor. Though mechanical prediction techniques intended to forecast post-injury rehabilitation outcomes such as RTW (employment) status (e.g., Blackwell et al., 2003; Gumerman, 1998; Hall, 1994; Hester et al., 1986), amount of time taken to RTW (e.g., Magrega et al., 1993) and job retention success (e.g., Vercillo, 2008) have previously been constructed, none were based on samples derived from a population of injured employees in Minnesota. This is of significance according to Hester and Decelles (1989) who found that their mechanical prediction technique (i.e., the Menninger Return to Work Scale) lost its capacity to predict RTW outcomes in a meaningful manner when applied to a sample of injured employees disparate from the population from which the scale was derived.

Regardless of the generalizability of the results of previous rehabilitation outcome studies, the findings from such studies provide guidance about possible explanatory variables that should be considered for inclusion into a predictive model of the RTW outcomes of injured Minnesota employees after receipt of VR benefits. For example, researchers frequently use demographic (e.g., age; sex; education; marital status; residence) variables when predicting various rehabilitation outcomes. Other common predictors include injury-related (e.g., nature of injury or illness; body part affected; severity of impairment; presence of pre-existing conditions), job-related (e.g., pre-injury occupation; pre-injury job tenure; pre-injury average weekly wage), service timeframe (e.g., time from date of injury to VR service initiation), and forensic (e.g., attorney involvement) variables.[8] Perhaps the most important insight that can be gleaned from previous rehabilitation outcome studies is that it is the exception rather than the norm when injury-related characteristics such as *medical impairment* (i.e., as measured by impairment type or severity) are sufficient predictors of *vocational disability* (i.e., as measured by RTW status). As indicated by Brehm and Rush (1988), individuals with disabilities are a unique subset of individuals with impairments and are identified by a multitude of factors, including their demographic and socioeconomic characteristics, rather than simply by the state of their health. This is also consistent with prominent disablement process models (Nagi, 1965; World Health Organization, 2001) which propose that the extent of an individual's disability (vocational or otherwise) attributable to an active pathology or health condition is a function of the interaction between the individual and his or her environment.

Horst, Wallin, and Guttman (1941) asserted that "the goal of research in prediction is to reduce as much as possible the individual, social, and economic waste resulting from trial and error methods of selection of persons for various types of activities" (p. 101). This is presumably because it is helpful for clinicians in any health-related field to know the probable outcome of an intervention before implementation. Accordingly, in the rehabilitation profession, *a priori* knowledge of the primary variables that are associated with RTW outcomes is likely a critical component of effective and efficient service provision. Not only does the supply of VR benefits to injured employees without RTW potential fail to help such individuals, it limits resources available to other injured employees with RTW potential. To avoid this resource misallocation, the development and validation of an objective, evidence-based method of predicting the RTW

[8] These explanatory variables can also be grouped according to broader factors based on theoretical considerations. According to disablement models such as the World Health Organization's International Classification of Functioning model, these factors generally include medical (e.g., severity of impairment), individual (e.g., education), and workplace (e.g., job tenure) factors.

outcomes of injured employees prior to service provision is needed. Guided by a disablement process framework and a rehabilitation literature review, this study was designed to do just that.

Purpose of Study

The purpose of this study was to identify the most parsimonious set of rehabilitation outcome explanatory variables, or disability risk factors (including medical, individual, and workplace factors), that precisely and accurately predicts the RTW status as of claim closure of injured employees who sustained permanent impairment and received VR services in Minnesota's workers' compensation system. Objective evidence of the relative importance of key RTW determinants will allow for the amelioration of the subjective clinical judgment method that is currently used for VR benefit eligibility determination. Study results will thus assist decision makers (e.g., qualified rehabilitation consultants) responsible for deciding which injured Minnesota employees possess RTW (and thus rehabilitation) potential and can benefit from receipt of VR services. Study results also will assist workers' compensation policy makers (e.g., Minnesota state legislators) by revealing any vulnerable populations (e.g., workers who are less educated, economically disadvantaged and/or living in rural areas) who, despite receipt of VR services in their current form, achieve successful RTW outcomes at lower rates relative to the general population of injured Minnesota employees.

Significance of Study

The significance of this study is rooted in the fact that "the scientific study of prediction in rehabilitation is important for the improvement of services to all clients" (Bolton, 1979, p. 135). Though Bolton made this statement more than 30 years ago, the importance of the accurate prediction of rehabilitation outcomes has not changed. This is because the VR benefit eligibility determination process in many disability support programs continues to heavily rely on rehabilitation professional predictions of RTW outcomes. For example, in many workers' compensation systems, injured employees deemed to possess RTW potential are awarded access to VR services as a preventive intervention (i.e., in an attempt to avoid long-term or permanent unemployment). This type of eligibility determination process puts a premium on the accurate assessment of RTW potential as poor prediction methods lead to resource misallocation, escalating costs, and undesirable outcomes.

As previously noted, recent data reveal troubling trends related to the provision of VR services in Minnesota's workers' compensation system. From the late 1990s through 2011, as the VR participation rate among injured employees with indemnity claims rose 55.6%, service costs per VR participant increased 22.3% and RTW rates declined 23.8%. Beyond these trends, there are additional signs that the existing rehabilitation consultation process that is relied upon for VR benefit eligibility determination needs to be improved (Berry & Zaidman, 2012, Chapter 4). Between 1998 and 2011, the percentage of qualified employees who completed their VR plan dropped from 61.0% to 44.8%. This is important as in 2011 approximately 98% of VR participants who completed their plan returned to work while only 22% of those who did not complete their plan returned to work as of plan closure. During this same period, there were positively-skewed distributions of VR service duration and costs in which mean duration was consistently at least 40% longer than median duration (e.g., mean VR service duration of 13.8 months and median VR service duration of 9.5 months in 2011) and mean costs were consistently at least 60% greater than median costs (e.g., mean VR service cost of $8,830 and median VR service cost of $5,410 in 2011). Also, in 2011, VR service duration averaged 12.1 months for those who did RTW and 16.8 months for those who did not RTW as of plan closure. Similarly, VR service costs for participants who completed their plan (and thus who almost invariably did RTW) averaged $6,280 while VR service costs for participants who did not complete their plan (and thus likely did not RTW) averaged $12,480 in 2011.

These service duration and cost figures clearly suggest that VR benefits are being disproportionately allocated to currently qualified employees who are *not* returning to work. That is, the qualified employee outliers who are contributing to the significant disparities in average and median VR service duration and costs are all too often not achieving the intended outcome of the benefit they are receiving. Ideally, VR benefit eligibility decision makers would be able to distinguish between injured employees who are in need of and will benefit from VR services and those who are either unable to RTW or who are able to RTW without services. Evidence indicates that the subjective rehabilitation consultation process that is presently being used in Minnesota's workers' compensation system has had limited success in accomplishing this aim. Consequently, a study to determine whether an objective, evidence-based method that precisely and accurately predicts RTW outcomes prior to service provision can be constructed is warranted.

Research Questions and Hypotheses

This study was guided by five research questions and associated hypotheses. These research questions and associated hypotheses are distinguished by their relevance to model development and validation and are presented below:

Model development.

- Research question 1: Does knowledge of the full set of RTW outcome predictor variables make a difference in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?

- Hypothesis 1: Knowledge of the full set of RTW outcome predictor variables does make a difference (i.e., is helpful) in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

- Research question 2: Can a more parsimonious RTW model be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 2: A reduced RTW model can be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.
- Research question 3: How well does the optimal RTW model (i.e., the most parsimonious model that reliably predicts the outcome) fit observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 3: Predicted RTW outcomes from the optimal RTW model are not significantly different from observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.
- Research question 4: How good is the optimal RTW model at classifying a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?

- Hypothesis 4: The ability of the optimal RTW model to classify a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Model validation.

- Research question 5: How good is the optimal RTW model at classifying a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
  - Hypothesis 5: The ability of the optimal RTW model to classify a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Delimitations

The following delimitations were established to narrow the scope of this study:

1. Only claims of injured Minnesota employees who sustained permanent impairment *and* who received VR benefits were included in this study.
2. Claims that satisfied the first two criteria (i.e., filed by injured employees who sustained permanent impairment and received VR benefits) must have also been filed between January 1, 2003 and December 31, 2011 in order to be included in the study.
3. All claims that were otherwise eligible for study inclusion but which possessed the following characteristics were excluded from this study: a) claim had missing data

regarding the variables of interest to this study;[9] b) claim was filed by an injured employee who was younger than age 18 or older than age 65 (in years); c) claim was filed by an injured employee who resided outside of Minnesota; d) claim was filed by an injured employee whose VR benefit was discontinued due to reasons other than VR plan closure and/or claim settlement (e.g., due to injured employee being dead or missing); e) claim was not closed by September 30, 2012.

Assumptions

The following assumptions were made when conducting this study:

1. All data gathered about the study's accessible population from the Minnesota Department of Labor and Industry's workers' compensation administrative claims database were accurate.
2. This study's accessible population of claims of injured employees who sustained permanent impairment and received VR benefits was representative of the total population of claims of injured employees who sustained permanent impairment and received VR benefits within the Minnesota Department of Labor and Industry's workers' compensation system (and potentially in other U.S. workers' compensation systems).
3. All claims included in this study's accessible population were made by injured Minnesota employees who were motivated to complete their individually tailored rehabilitation plan in order to achieve the vocational goal of attaining suitable gainful employment.
4. There was no significant difference in the quality of VR services delivered by qualified rehabilitation consultants to injured Minnesota employees whose claims were included in this study.

[9] The one exception to this eligibility criterion, for reasons discussed in the Methodology chapter, was with respect to severity of permanent impairment.

5. An injured employee's RTW status as of claim closure is a reasonable proxy measure of his or her RTW potential.

Organization of Study

The remainder of this study is organized into four chapters as well as references and appendices. Chapter 2 presents a systemic overview of workers' compensation, a disablement process framework, and a review of current literature related to rehabilitation outcome prediction. Chapter 3 delineates the study's research design and methodology and offers a description of the process of RTW outcome model development and validation. Chapter 4 includes a data analysis with interpretation and discussion of study findings. Chapter 5 contains a study summary in addition to conclusions and recommendations based on study results. The study concludes with references and appendices (including definitions of key terms provided in Appendix A).

Chapter 2: Literature Review

Introduction

Prior to conducting this RTW outcomes study, a literature review was performed with three overarching goals in mind: to learn about workers' compensation systems and common methods of measuring work disability within these systems; to identify a conceptual framework that offers direction to the development of a predictive model of RTW potential; to become familiar with relevant research exploring the explanatory value of various prognostic factors associated with RTW. This chapter is structured according to these aims and contains the following three major sections: 1) U.S. Workers' Compensation Systems: An Overview;[10] 2) The Disablement Process: A Conceptual Framework for Assessing RTW Potential; and 3) Predicting RTW Outcomes: A Selective Search and Critical Review. A summary of literature review findings is also presented.

U.S. Workers' Compensation Systems: An Overview

Workers' compensation is a form of social insurance designed to provide protection to employees who sustain on-the-job injuries. The first formal workers' compensation laws were passed in Europe following the Industrial Revolution, first in Germany in 1884 (Workers' Accident Insurance) and later in England in 1897 (Workmen's Compensation Act). Other western nations, including the U.S., soon followed suit. The impetus for the enactment of

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[10] Given the setting of this study, where appropriate, specific aspects of Minnesota's workers' compensation system were used when providing examples of common characteristics of U.S. workers' compensation systems.

workers' compensation statutes was the recognition that the hazards of an increasingly industrial society were too costly to maintain the status quo (Guyton, 1999). Prior to the passage of such laws, the only recourse for employees who had sustained work-related injuries was to file a civil (e.g., personal injury) lawsuit against their employer. In order to recover damages, employees were faced with the difficult task of proving that their injury was the fault of their employer.[11] This adversarial process was often expensive for the employee and employer. For the employee, much needed medical treatment was either foregone or paid out-of-pocket until the case was settled (and possibly after settlement depending on the result). For the employer, there was substantial financial risk associated with disputes over work-related injuries being resolved in court (e.g., excessive jury awards). The intention of workers' compensation lawmakers was to minimize, if not avoid, the mounting conflict between business and labor regarding resolution of disagreements over on-the-job injuries. To accomplish this objective, workers' compensation systems were designed as "no-fault" insurance programs (Burton, 2007, p. 23). In such systems, injured employees are assured limited coverage in exchange for forfeiting their right to sue their employer. This compromise between business and labor is known as the "compensation bargain" and is the signature feature of workers' compensation systems (Burton & Mitchell, 2003).

Though work-related injuries continue to cause friction in employee-employer relationships, the statutory compromise between the two parties that is mandated in workers' compensation law has endured over time. In fact, since its emergence in the U.S. in the early

[11] Employers made frequent use of three common-law rules to defend themselves against work-related injury claims made by employees: contributory negligence; fellow-servant doctrine; assumption-of-risk doctrine (Clayton, 2003/2004). Contributory negligence prevented employees who were injured in part due to their own negligence from being entitled to any damages. The fellow-servant doctrine freed employers of liability when an employee was injured as a result of the negligence of a fellow employee. Finally, the assumption of risk doctrine was used to limit employer liability on the basis that employees were aware of any workplace hazards and assumed the risk of injury or death as a result of those hazards through their voluntary employment.

1900s, workers' compensation has become an important part of American social insurance (Sengupta et al., 2011, p. 2). Currently, there are workers' compensation systems in all fifty states and the District of Columbia that serve injured employees working for private companies or state and local government agencies. There are also workers' compensation systems at the federal level that serve federal civilian employees as well as other specific employee groups (e.g., longshore, harbor, and other maritime workers; coal miners with black lung disease) (Sengupta et al., p. 4).

Each workers' compensation system in the U.S., whether at the state or federal level, is governed by a unique set of statutory policies. These statutes specify the rules and regulations to be followed by all parties involved in a workers' compensation claim, including injured employees, employers, insurers, attorneys, and medical and allied health professionals (including qualified rehabilitation consultants) (Betters, 2006). While the principle of liability without fault is the theoretical basis for workers' compensation in America, statutes guiding the implementation of this principle vary significantly across systems (Matkin, 1985, p. 13). American workers' compensation systems differ in several respects, including but not limited to employee coverage, injury and illness compensability, benefit allocation, and administrative practices. Of all of the differences among workers' compensation systems in the U.S., perhaps the source of greatest variation is in regards to the determination of proper compensation to injured employees who have sustained a permanent disability (Barth, 2003/2004). There is particular variation in determining the amount of benefits to be paid to injured employees who have sustained a permanent partial disability (PPD). Identification of the most suitable method (as determined by accuracy or cost-effectiveness) of awarding PPD benefits to entitled injured employees has long been a focus of workers' compensation research (e.g., Berkowitz & Burton, 1987; Barth & Niss, 1999; Durbin & Kish, 1998; Park & Butler, 2000; Burton, 2005). PPD claims are often investigated because they comprise a significant portion of all benefits paid to employees in American workers' compensation systems (e.g., PPD claims accounted for 53.0% of total benefits paid in Minnesota in 2008). Despite this attention, the enduring intersystem differences in the approach to this issue reveal that consensus on the best method for determining the amount of benefits to be paid in PPD claims is lacking.

It is likely that the disparity among workers' compensation systems in the methods used to determine PPD benefits is largely a function of the inherent complexity in assessing the degree of permanent disability attributable to a particular work-related injury. This inherent complexity is evidenced by the failure of many workers' compensation systems to distinguish between *impairment* and *disability*. Impairment is a significant deviation, loss, or loss of use of any body structure or body function in an individual with a health condition, disorder, or disease (Rondinelli et al., 2008. p. 5). Disability, on the other hand, is an inability to perform or a limitation in performing socially defined roles and tasks (e.g., working and earning money) expected of an individual within a sociocultural and physical environment (Nagi, 1991, p. 315). A key distinction between impairment and disability is that impairment is entirely within a person whereas disability is a function of the interaction between a person and his or her environment. Consequently, an individual's impairment is often more easily identifiable and measurable than his or her disability (regardless of whether the disability is of a vocational, psychological, social, or economic nature) (Nagi, 1965, p. 108). As a result, in American workers' compensation systems, estimates of an injured employee's medical impairment are commonly used as proxy measures of vocational disability. This is in spite of the widely accepted notion that impairment is merely one of many determinants of disablement (Rondinelli et al., 2008, p. 5).

The workers' compensation process for injured employees who are out of work beyond the statutory waiting period (e.g., typically a period of three or seven days beyond which injured employees who remain out of work qualify for indemnity benefits[12]) offers a clear distinction between the constructs of impairment and disability. Any indemnity benefits awarded to an injured employee are classified as temporary (either partial or total) disability benefits until he or she has been determined to have reached maximum medical improvement (MMI). MMI status is assigned to injured employees, usually by a treating physician, at a date after which no further significant recovery from or significant lasting improvement to a personal injury can reasonably be anticipated, based upon reasonable medical probability, irrespective and regardless of subjective complaints of pain (Minnesota Statutes 2011, section 176.011, subdivision 13a). As of this date, any medical impairment that an injured employee has sustained is considered permanent. In addition to making decisions about permanent medical impairment, treating and/or evaluating physicians are responsible for assessing whether an injured employee has sustained any *functional limitations* attributable to his or her work-related injury. Functional limitations are performance restrictions that occur at the whole person level (Jette, 2006, p. 728) and are the most direct way through which impairment contributes to disability (Nagi, 1991, p. 314-315). In most workers' compensation systems, including Minnesota's, injured employees who possess permanent functional limitations that prevent them from returning to their pre-injury occupation but do not completely erode their labor market access are entitled to VR benefits.

[12] In Minnesota, the waiting period starts on the first day of any lost time and lasts for three calendar days. Indemnity benefits are not paid for the waiting period unless the injured employee's disability (i.e., inability to work) continues for 10 calendar days or longer (Minnesota Statutes 2011, section 176.121).

Thus, medical rehabilitation is focused on minimizing an injured employee's impairment prior to the date of MMI whereas vocational rehabilitation is focused on minimizing his or her disability after the date of MMI.

In theory, the primary if not sole, purpose of disability benefits (whether temporary or permanent in nature) in American workers' compensation systems is to partially replace injured employees' lost wages. The determination of temporary disability benefits is relatively straightforward as an injured employee typically receives a preset percentage (often two-thirds) of his or her pre-injury wage until MMI is achieved. However, the determination of permanent disability benefits often becomes convoluted when an injured employee's permanent impairment rating is used as a proxy for his or her potential future wage loss. This approach to awarding PPD benefits confounds the impairment and disability constructs by assuming that any reduction in an injured employee's ability to RTW at his or her pre-injury wage level is fully explained by the extent of his or her medical impairment. The faulty logic of automatically equating impairment with disability can be demonstrated with an example of how two individuals with the same type of injury and degree of impairment can have a considerably different level of disability. For instance, consider a 35-year old with a doctorate degree who works as a clinical psychologist and a 55-year old high school dropout who works as an ironworker. If both individuals undergo a below-the-knee amputation as a result of work-related injuries they would have an identical impairment rating. In addition, if both individuals are permanently limited to sedentary exertion and require ambulatory assistance, the ironworker will be much less likely to be able to return to his or her pre-injury wage level than the clinical psychologist. Thus, taking into account non-medical factors such as age, education, and work history, the ironworker's degree of disability (i.e., as measured by wage loss) is likely to be much higher than that of the clinical psychologist.

Even with evidence that medical impairment explains minimal variance in wage loss among injured employees (e.g., Park & Butler, 2000), impairment ratings are still commonly used as surrogate measures of the severity of an injured employee's disability. In most state workers' compensation systems in the U.S., injured employees who have sustained a permanent impairment to certain body parts are entitled to PPD benefits regardless of the impact of their injuries on their ability to work and earn money. Currently, there are about 44 state workers' compensation systems that have a *disability schedule* that specifies the amount of benefits to be paid for impairments to particular body parts (Sengupta et al., 2013, p. 7).[13] All disability schedules account for upper and lower extremity impairments and many also account for visual and/or hearing impairments. There are a few state workers' compensation systems, including Minnesota's, that have disability schedules that are practically all-inclusive in terms of the types of injury (by body part) that are covered. Consequently, PPD benefits in Minnesota (and other systems with all-inclusive disability schedules) are based on the injured employee's medical impairment rating and are unrelated to wage loss (Berry & Zaidman, 2013, p. 13).

As most American workers' compensation systems do not have all-inclusive disability schedules, methods have been adopted to determine the amount of PPD benefits to which an injured employee with an unscheduled disability (i.e., disability attributable to a work-related injury or illness to certain body parts not covered on a disability schedule such as the spine, internal organs, or head) is entitled. While PPD benefits awarded for compensation of a

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[13] Strictly speaking, these schedules should be titled *impairment* rather than *disability* schedules as they specify permanent partial awards that are based on impairment and not on disability. Similarly, the benefits awarded based on these schedules would more accurately be termed permanent partial impairment (PPI) rather than permanent partial disability (PPD) benefits.

scheduled disability are strictly based on an injured employee's impairment, PPD benefits awarded for compensation of an unscheduled disability may be based on an injured employee's impairment, disability, or a combination of both. The following are the four approaches to the determination of the amount of PPD benefits to be awarded for unscheduled disabilities that are presently used in U.S. workers' compensation systems: 1) impairment-based approach; 2) loss of wage-earning capacity approach; 3) wage loss approach; and 4) bifurcated approach. Among the 50 state workers' compensation systems in the U.S., 19 use an impairment-based approach, 12 use a loss of wage-earning capacity approach, 10 use a wage loss approach, and the remaining nine states (as well as the District of Columbia) use a bifurcated approach (Sengupta et al., 2013, p.7). Under the impairment-based approach, unscheduled disabilities are treated much like scheduled disabilities in that an injured employee's PPD benefits are based on degree of impairment without consideration of the labor market consequences of the injury.[14] Conversely, under the loss of wage-earning capacity and wage loss approaches, PPD benefits for unscheduled disabilities are based on an injured employee's anticipated loss of wage-earning capacity or actual wage loss. Though there are often disputes over the extent and/or cause of an injured employee's future loss of wage-earning capacity or present wage loss with the use of these approaches, the confounding of the constructs of impairment and disability is avoided (at least with respect to unscheduled PPDs). Finally, under the bifurcated approach, the benefit for a PPD depends on an injured employee's employment status after MMI is reached (Barth, 2004). If an injured employee has reached MMI and has returned to work at or near his or her pre-injury wage level, PPD benefits are based on the degree of impairment. However, if an injured

[14] A few states using the impairment-based approach do offer an additional benefit to injured employees who have not returned to work at or near their pre-injury wage level after their PPD benefits have concluded. Also, Colorado and Nevada adjust PPD benefit awards according to an injured employee's age (Barth, 2004).

employee has reached MMI but has not returned to work at or near his or her pre-injury wage level, PPD benefits are based on anticipated loss of wage-earning capacity attributable to the work-related injury.

The attraction of using an injured employee's medical impairment rating as a proxy measure of his or her degree of disability as a result of a work-related injury may be due to the relative consistency that accompanies such a method. Equating impairment with disability avoids the inevitable variation in the awarding of PPD benefits due to the consideration of non-medical factors (e.g., age; education; pre-injury occupation). The shortcoming with such a method is that it values reliability over validity. Even if two injured employees have the same degree of impairment, this does not mean that the two injured workers also have the same degree of functional limitation or wage loss arising from their work-related injuries. Thus, the all too common consequence of using an impairment-based approach (including disability schedules) is that injured employees are inaccurately compensated for their PPDs (Park & Butler, 2000). Perhaps because of this reality, there are four state workers' compensation systems (i.e., Massachusetts, Montana, Oregon, and Rhode Island) that now offer two types of permanent partial benefits to eligible injured employees (Sengupta et al., 2011). One compensates injured employees for economic loss (i.e., disability benefits) while the other compensates them for non-economic loss (i.e., impairment benefits) (Burton, 2008). This dual approach to PPD benefits is theoretically appealing as it avoids the confounding of impairment and disability.

It is noteworthy that even workers' compensation systems that base PPD benefits on medical impairment (e.g., Minnesota) typically offer some form of VR benefits to injured employees. This is interesting in that receipt of VR services can diminish an injured employee's disability but cannot reduce his or her impairment. The justification for providing VR benefits to eligible injured employees in such systems is thus less clear than those that base PPD benefits on loss of wage-earning capacity or actual wage loss. For example, in workers' compensation systems using these economic loss approaches to determining compensation for unscheduled disabilities, the provision of VR services can help minimize the amount of PPD benefits paid to an injured employee by helping him or her RTW in a position that maximizes his or her residual wage-earning capacity. Conversely, in systems that use an impairment-based approach, PPD benefits are unrelated to wages (or wage-earning capacity). Without an ability to affect PPD benefit awards, the only logical rationale for providing VR benefits to qualified employees in systems that base PPD benefits strictly on impairment is to minimize the number of injured employees who may otherwise eventually develop a permanent and total disability (PTD) due to an inability to RTW on their own. It is also possible that the provision of VR services has been a part of many U.S. workers' compensation systems for so long that it is inherently accepted as a benefit to eligible injured employees along with medical and indemnity benefits.

Making a distinction between impairment and disability is particularly important to the development of a predictive model of RTW outcomes because disability and rehabilitation (or RTW) potential are very closely related phenomena (Nagi, 1965, p. 108). The more severe an injured employee's permanent disability, the less potential he or she has to be successfully rehabilitated and to RTW. Individuals such as qualified rehabilitation consultants in Minnesota's workers' compensation system tasked with making decisions about which injured employees are eligible for VR benefits must therefore be knowledgeable about the contributing factors to disability. It is clear that an injured employee's impairment is merely one of many contributing factors to his or her disability. Likewise, an injured employee's impairment is not the sole, or even necessarily a key, determinant of his or her RTW potential. To learn more about both medical and non-medical factors that can influence an injured employee's permanent disability and RTW potential, a review of disablement process models was conducted. A detailed summary of this review, with particular emphasis on Nagi's disablement model and the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) model, is provided in the following section.

The Disablement Process: A Conceptual Framework for Assessing RTW Potential

The term "disablement" refers to the "various impacts of chronic and acute conditions on the functioning of specific body systems (impairment), on basic human performance (functional limitations), and on people's functioning in necessary, usual, expected, and personally desired roles in society (disability)" (Jette, 1994). Based on this definition, disablement represents the functional consequences of illness and injury expressed at the body system, whole person, and societal levels. This conceptualization of disablement suggests that disability is not purely a personal characteristic but rather is a lack of correspondence between a person's residual abilities and an environment's demands. As this disablement concept has gained acceptance across many rehabilitation-related disciplines, disability has become recognized as a multidimensional construct that is dependent on contextual (personal and environmental) factors. In addition, over the past half century, several disablement models have been developed that provide frameworks for understanding how individuals with the same injury or illness can have drastically different rehabilitation (e.g., RTW) outcomes. These disablement models offer valuable guidance to anyone attempting to accurately predict an individual's (e.g., injured employee) rehabilitation potential after the onset of a health condition (e.g., work-related injury).

Contemporary disablement models originated with the seminal work of sociologist Saad Z. Nagi in the 1960s. Nagi's disablement model, which is presented in Figure 1, was first

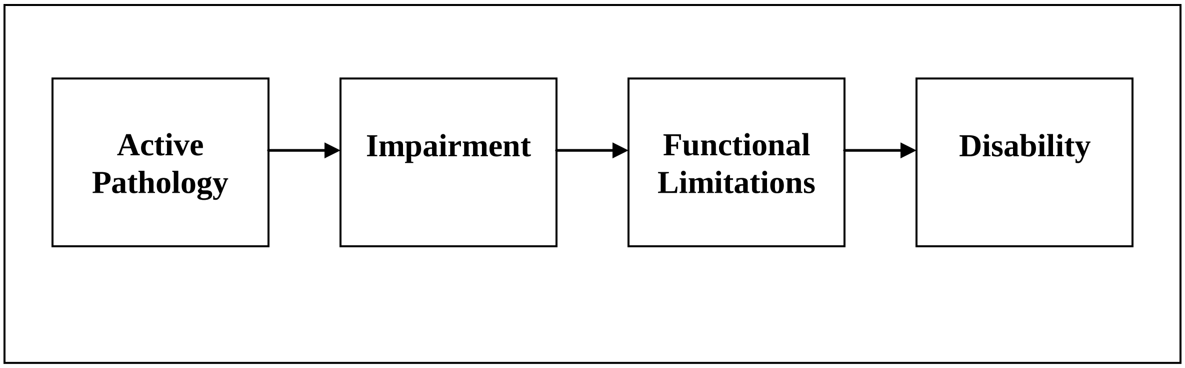

Figure 1. Nagi's Disablement Model.

introduced in 1965. With this model, Nagi offered a framework that distinguishes disability, which he considered basic to the field of rehabilitation, from other distinct but closely related health conditions (Nagi, 1965, p. 100-101). Nagi specifically made distinctions among the following four interrelated constructs: active pathology; impairment; functional limitations; disability. He described *active pathology* as a concurrent, two-step process that includes the onset of disease (e.g., via infection, trauma, metabolic imbalance, or degenerative process) accompanied by a person's attempts to return to a normal state. An example of an active pathology would be the presence of spinal disc herniations at the L4-L5 and L5-S1 levels in a female certified nurse assistant (CNA) following a work-related injury. An *impairment* was originally described by Nagi as an anatomical or physiological abnormality or loss. He later updated this description to include mental and emotional as well as anatomical and physiological deviations (Nagi, 1991, p. 314). Possible impairments that may impact the CNA with the spinal disc herniations include reductions in range of motion in her lumbar spine and/or muscular strength in her lower back. According to Nagi, impairments can (but do not necessarily) impose *functional limitations* on an individual's ability to perform specific tasks or activities. Nagi viewed functional limitations as the primary mediating factor between impairment and disability. For the CNA with the lumbar spine injury, possible functional limitations include limitations in her ability to lift/carry or push/pull (e.g., limited to lifting and carrying or pushing and pulling 20 pounds occasionally or 10 pounds frequently) and/or to stand or walk (e.g., limited to standing and/or walking about four hours in an eight-hour workday). Finally, Nagi characterized *disability* as an inability to perform or a limitation in performing socially defined roles and tasks expected of an individual within a sociocultural and physical environment (Nagi, 1991, p. 315). The injured CNA may experience disability in several ways, such as difficulties in performing daily-living activities (e.g., showering; dressing), participating in hobbies (e.g., horseback riding; gardening), or fulfilling societal roles (e.g., working as a nurse assistant; serving as a volunteer caregiver in her community).

Nagi identified at least three ways of making distinctions among active pathology, impairment, functional limitations, and disability (Nagi, 1965). One method of differentiating among these four constructs is the level at which they occur. Active pathology occurs at the cellular level and invariably leads to impairment (temporary or permanent) which is manifested at the tissue, organ, or body system level (Jette, 2006). Functional limitations occur at the whole person level while disability exists on a societal level and is demonstrated when a person experiences difficulty performing certain activities within one or more typical life domains (e.g., work; school; recreation). A second method of differentiating among the four Nagi disablement model constructs becomes evident with the presence of one construct in the absence of one or more of the other constructs. For example, impairment can be present without an active pathology. This can occur after a disease process has resolved (e.g., healed humerus fracture with residual arm weakness) or as a result of a congenital deformity (e.g., congenital finger fusion resulting in limited range of motion in the fingers). Similarly, some impairments do not result in functional limitations. Deficits in joint mobility or muscle strength do not inherently lead to limitations in performing activities such as lifting, standing, reaching, stooping, or climbing. In addition, disability can occur without an impairment or functional limitations. A case in point is an individual with a history of mental illness in remission who may nevertheless have difficulty obtaining employment due to employer stigmatization or discrimination. A third method of differentiating among Nagi's disablement model constructs is by the treatment that is directed toward each construct. Treatment of pathology often comes in the form of medication or surgery and is typically provided by health care professionals such as physicians and surgeons. Treatment of impairment and functional limitations is aimed at maximizing an individual's residual functioning (at various levels) and is usually provided by other health care professionals such as physical, occupational, and speech-language therapists. Lastly, treatment of disability is focused on minimizing or eliminating any gaps between an individual's residual abilities and an environment's demands and, particularly in a vocational context, is customarily provided by rehabilitation counselors.

Perhaps the greatest contribution of the Nagi disablement model was that it altered the prevailing perception of disability as primarily, if not solely, a personal attribute. Nagi (1969) referred to disability as a "pattern of behavior" (p. 12) that is principally influenced by impairment-related (e.g., whether an impairment is permanent and what, if any, functional limitations are imposed), personal (e.g., an individual's definition of his or her situation such as reactions to impairment and motivations for minimizing its consequences), and environmental (e.g., definition of an individual's situation by his or her significant others) factors. By describing disability as a relational concept that is dependent on multiple factors, Nagi helped demonstrate through his disablement model why there is often significant variation in the degree of disability among individuals with the same or similar diagnoses and impairments. Nagi also tied his conceptualization of disability to the closely related construct of rehabilitation potential. In particular, Nagi believed that "the latter [rehabilitation potential] is largely a prognostication of the former [disability]" (1969, p. 15). Thus, while acknowledging that the process of determining an individual's rehabilitation potential (and thereby extent of disability) is complex, Nagi made clear that any such attempt must consider the contributions of both personal and environmental as well as impairment-related factors.

Following the introduction of Nagi's original disablement model in 1965, the major conceptual frameworks pertaining to disability have been developed by the World Health Organization (WHO). The WHO developed its first disablement model, dubbed the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) model, in 1980 (WHO, 1980). The WHO's ICIDH model is conceptually similar to Nagi's disablement model in that it includes four distinct concepts related to and including disability and extends across these concepts in a linear manner. However, the terminology is different in the ICIDH model as the four dimensions are pathology, impairment, disability, and handicap. While pathology and impairment are analogous in the two conceptual frameworks, disability in the WHO's ICIDH model is most comparable to functional limitations in Nagi's disablement model. Also, handicap in the WHO's ICIDH model corresponds to disability in Nagi's disablement model. Despite these differences in terminology, the developers of both frameworks proposed that an individual's ability to perform activities and societal roles is dependent on both personal and environmental attributes (Pope & Tarlov, 1991).

The WHO's ICIDH model, like Nagi's disablement model, represents a move away from a medical model of disease. Neither model views disability as a problem of the person exclusively caused by a pathology or health condition. In this regard, both frameworks have been influential in promoting a greater understanding of the important role of social factors in the consequences of disease. However, there are shortcomings of the two models. For example, the unidirectional representation of the relationships among the four concepts in both frameworks implies causation. Both disablement models have thus been viewed as overly simplistic and lacking sufficient detail about the contextual factors that contribute to disability (in Nagi's disablement model) or to handicap (in the WHO's ICIDH model) (Gray & Hendershot, 2000; Rondinelli et al., 2008). In response to such criticism, the WHO has revised the original ICIDH model. The WHO released the second version of the model, the ICIDH-2, in 1997. Several changes were made to the ICIDH model in this revision, including a transformation of terminology to emphasize enablement rather than disablement (Rondinelli et al., 2008). Further model modifications by the WHO, including a new title, led to the creation of the International Classification of Functioning, Disability, and Health (ICF) model in 2001. Unlike the ICIDH, the ICF has been endorsed for international use by the World Health Assembly (WHO, 2001). The ICF model also "holds great promise to provide a synthesis of earlier models of disablement and to provide the rehabilitation disciplines with a universal language with which to discuss disability and related phenomena" (Jette, 2006, p. 733).

Relative to its predecessors (e.g., Nagi's disablement model; WHO's ICIDH model), the ICF disablement model offers a more comprehensive framework in recognition of the complex and dynamic nature of the disablement process. The ICF model is presented in Figure 2 and has two interrelated parts, the first of which pertains to functioning and disability and the second of which pertains to contextual factors (WHO, 2001). The first part of the model includes three components: 1) body functions and structures; 2) activities; and 3) participation. Through these three components, the ICF model attempts to account for the potential impact of an individual's

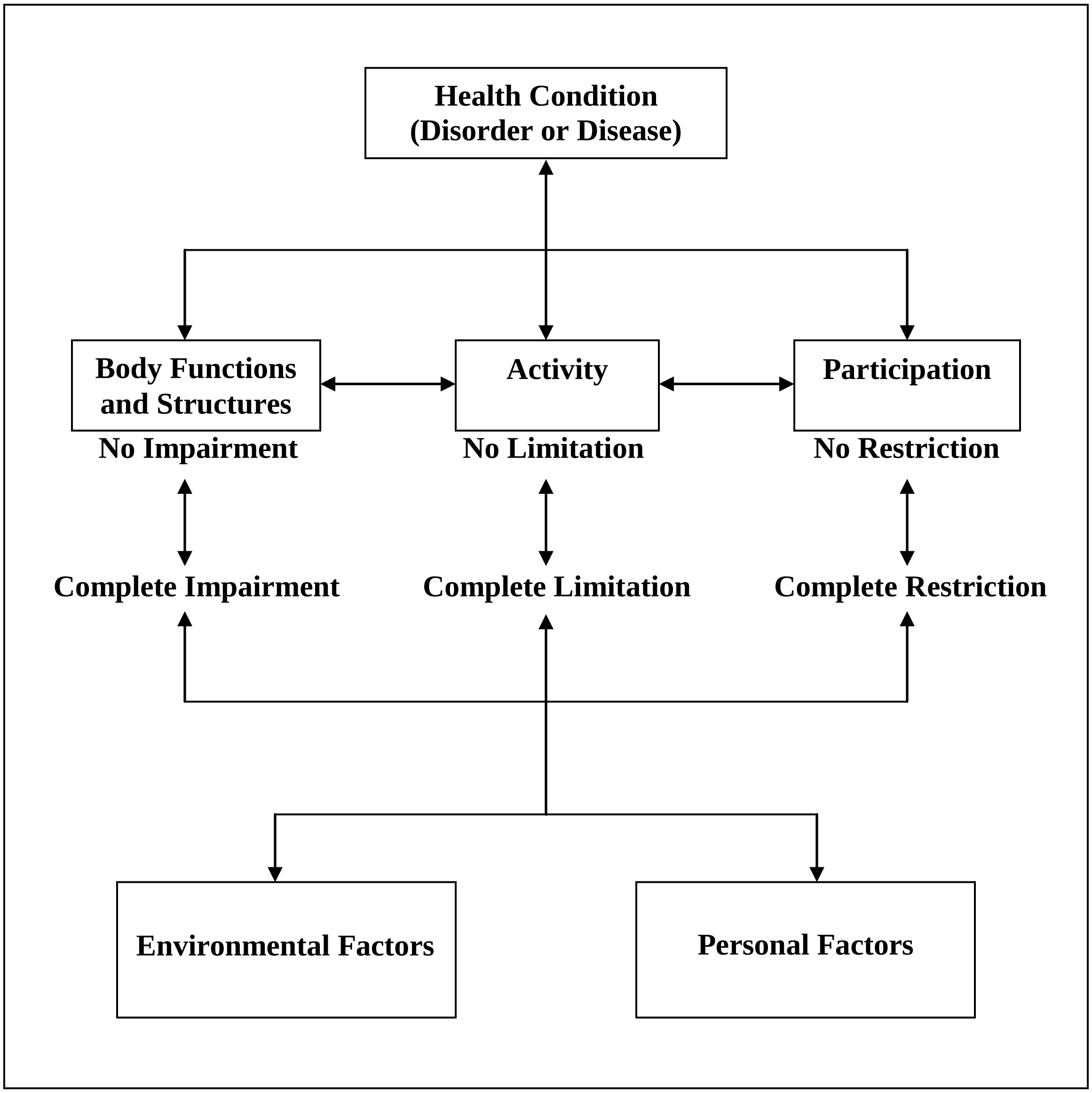

Figure 2. WHO's ICF Disablement Model.

health condition(s) at the body (body functions or structures), individual (activities), and societal (participation) levels. To the extent that disability is present at any of these levels, it is expressed by impairment of body function or structure, activity limitations, and/or participation restrictions. However, in their ICF model, the WHO suggests that health conditions are not the sole cause of, or contributor to, functional deficits. This is the basis for the second part of the model which includes two components: 1) personal factors; and 2) environmental factors. The ICF model includes these contextual factors to account for internal (personal) and external (environmental) influences on the functioning and disability of an individual with one or more health conditions. These personal (e.g., age; education; motivation) and environmental (e.g., assistive technology; social support; employer attitudes) factors can help or hinder an individual's ability to maximize his or her functioning and minimize his or her disability. Additionally, the key components of both parts of the ICF model are assumed to have bidirectional influences as a method of acknowledging the intricacies of the disablement process.

In developing the ICF model, the WHO elected to focus on the "components of health" rather than the "consequences of disease" (WHO, 2001). Accordingly, the ICIDH terms of *impairment*, *disability*, and *handicap* were replaced with the terms *body functions and structures*, *activities*, and *participation*. A primary purpose of this change in terminology was to allow for the description of both positive (i.e., functioning) and negative (i.e., disability) aspects of health. Along with the addition of contextual factors, the change in terminology is a key component of the ICF model's portrayal of the associations among its constructs in a "causally interactive" rather than "linearly predictive" manner (Rondinelli et al., 2008, p. 5). The inclusion of positive and negative aspects of the model's constructs makes clear that impairments, activity limitations, and participation restrictions are not necessarily inevitable, static consequences of a health condition (e.g., disease; disorder; injury; trauma). Rather, an individual's level of functioning and extent of disability in a particular domain (e.g., work and employment) are dependent on the dynamic interactions between health conditions and contextual factors (WHO, 2001, p. 10).

The inclusion of contextual factors in the ICF model helps explain how individuals with the same health condition(s) can have considerably different functional outcomes at the body, individual, and/or societal levels. Impairments, activity limitations, and/or participation restrictions are likely to decrease as a result of contextual facilitators and to increase as a result of contextual barriers. For example, considering the ICF model's work and employment domain, an injured employee with personal (e.g., younger age; high level of motivation) or environmental (e.g., accommodating employer; access to assistive technology) facilitators is more likely to make a successful work adjustment than an individual either without these facilitators or with personal (e.g., limited education; poor ability to cope) or environmental (e.g., employer stigma; lack of social support) barriers. Thus, according to the ICF model, health care professionals (e.g., qualified rehabilitation consultants in Minnesota's workers' compensation system) responsible for making decisions about whether individuals can benefit from interventions at any level of functioning (i.e., body; individual; societal) must be able to identify relevant contextual factors that may have enabling or disabling effects.

A comparison of Nagi's disablement model and the WHO's ICF model reveals that the two conceptual frameworks are different in several respects. The two disablement models are perhaps most notably disparate with respect to terminology, directionality, and complexity. However, as depicted in Figure 3, there is also significant overlap in the major dimensions of the two models. This overlap is a result of model agreement regarding the various levels at which functional deficits (or disablement) can occur. Recall the example of a female CNA who sustained a work-related injury that resulted in spinal disc herniations at the L4-L5 and L5-S1 levels. The CNA's L4-L5 and L5-S1 disc herniations would be known as an active pathology by Nagi and a health condition by the WHO. Similarly, both models account for the possibility of functional (e.g., functional disturbances in joint mobility or muscle power) and/or structural (e.g., spinal cord compression) impairment as a result of the work-related injury. Any limitations (e.g., mobility limitations such as an inability to stand and walk for extended periods) in the CNA's

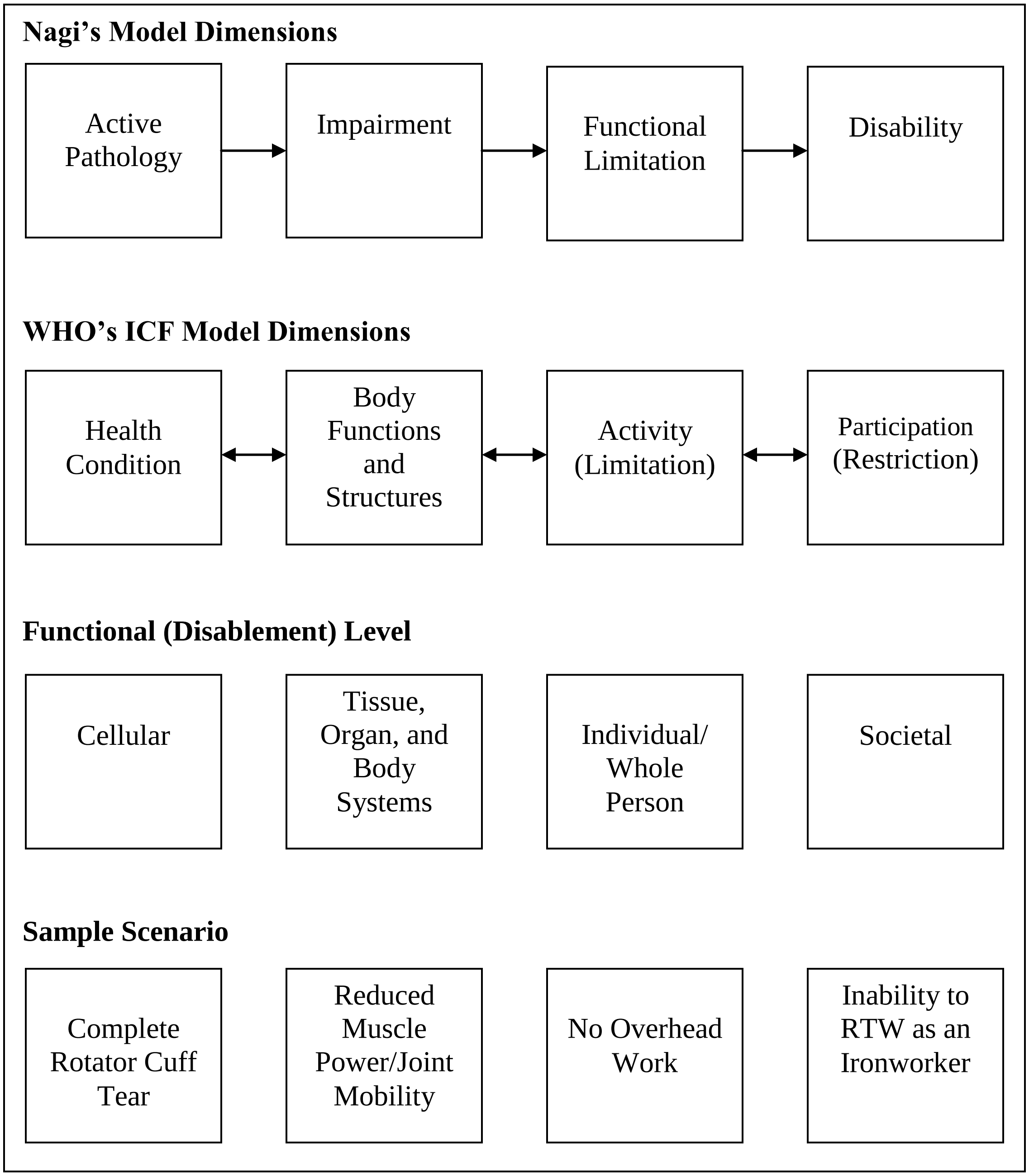

Figure 3. Disablement Model Comparison.

capacity to complete various tasks or actions would be considered functional limitations by Nagi and activity limitations by the WHO. Finally, any deficits in the CNA's performance of social roles (e.g., returning to work providing direct patient care) would be regarded as a disability by Nagi and as a participation restriction by the WHO.

The most important similarity between Nagi's disablement model and the WHO's ICF model is that both use a "biopsychosocial" approach to human functioning. This approach represents an integration of the medical and social models of disability. The medical model views disability as a personal characteristic that is directly caused by a health condition whereas the social model views disability as an environmental characteristic that is a socially created problem (Jette, 2006). The biopsychosocial model blends these two competing perspectives and views disability as a consequence of biological (e.g., biomedical), psychological (e.g., personal), and societal (e.g., environmental) forces. Though the inclusion of personal and environmental factors as contributors to disability is clearer in the WHO's ICF model than in Nagi's disablement model, Nagi's writings reveal his conviction that disability is dependent on the relationship between a person's abilities and an environment's (social and physical) demands (e.g., Nagi, 1991, p. 317). Another similarity between the two models is they both account for functional deficits at the body system (tissue and organ), whole person, and societal levels. Both models also suggest that an injured or ill individual's degree of disability, and thus rehabilitation potential, is ultimately the result of a complex interaction of biomedical, personal, *and* environmental factors. Guided by the biopsychosocial approach that typifies these two disablement models, a critical review of existing literature on the prediction of RTW outcomes was performed. This research review was instrumental in generating a list of variables worthy of inclusion in this RTW outcomes study and is discussed in the following section.

Predicting RTW Outcomes: A Selective Search and Critical Review

This literature review was performed with the primary intention of discovering the prognostic (or risk) factors that are most significantly associated with an individual's work disability as measured by his or her RTW outcome. To accomplish this goal, a structured approach to the review process was taken. This involved the development of a literature search strategy to assist with the selection of relevant publications as well as a data extraction plan to provide direction for the critical review. Information obtained from all included studies was then analyzed and synthesized in an attempt to learn about the current state of RTW literature. In addition to identifying key RTW outcome predictors, included studies were investigated to learn about trends regarding issues such as the populations being examined, common methods of analysis, and the significance of results. The process and outcome of this critical review is described below.

Search strategy.

Given the continually growing body of research investigating the primary predictors of various rehabilitation outcomes, conducting an exhaustive literature review is becoming increasingly difficult. This structured literature review was nevertheless intended to provide a comprehensive summary of literature relevant to this study's purpose. Specifically, a selective literature search followed by a critical review was performed to aid in accomplishing this study's chief objective: to identify prognostic factors related to RTW outcomes (i.e., a distinct type of rehabilitation outcome). The search strategy employed to assist with this review process involved multiple methods and began with the use of seven electronic bibliographic databases, including Academic Search Complete, Cumulative Index of Nursing and Allied Health Literature (CINAHL), ProQuest Dissertations and Theses, PsycINFO, PubMed/MEDLINE, ScienceDirect, and the Social Sciences Citation Index. To be inclusive, the initial parameters of this electronic database search were limited to three basic criteria. These three search criteria were that research documents be published no earlier than 1997 (i.e., within 15 years of the beginning of this literature search), be reported in English, and be available in full text. After application of these criteria, each of the above-listed databases was searched for relevant literature using Boolean operators along with the following primary key search terms: return to work; work disability; predictive model; biopsychosocial; predictor; outcome (including employment, vocational, and rehabilitation).[15] Given the abundance of results obtained, the abstracts (and sometimes the full text) of identified documents (e.g., journal articles; doctoral dissertations) were then scanned and literature that appeared relevant (e.g., evidence of a RTW outcome measure) was screened according to the following additional search criteria:[16]

1. Study included a rehabilitation outcome specifically related to employment or RTW status that was defined and measurable;
2. Study authors clearly identified the study's objectives as well as their methods with respect to sample selection, study design, data collection, and statistical analysis;
3. A study objective was to develop and/or validate a predictive model of RTW outcomes;
4. Study included multiple independent variables that represented medical and non-medical (e.g., personal and environmental) factors; and
5. Study design and statistical analysis were appropriate given the study's overall objective and research questions.

This targeted electronic database search resulted in the identification of 29 research documents that satisfied each of the search criteria. At this stage of the search process, an ancestry approach was taken as another method to ensure that relevant RTW research was

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[15] Secondary key search terms included "predict", "predicting", "determinant", and "risk factor" to account for variations of *predictor* and "prediction model" and "prognostic model" to account for variations of *predictive model*.

[16] The results were likely numerous in large part due to the lack of focus on the RTW outcomes of individuals with a specific health condition (e.g., traumatic brain injury). As work-related injuries result in a myriad of health conditions, this researcher elected to target publications with similar objectives to his own study (e.g., development of a predictive model of RTW outcomes) and of sound methodological quality (e.g., appropriate study design and statistical analysis to accomplish study objectives and to answer research questions).

thoroughly reviewed. The ancestry search involved the review of the reference lists of all identified documents that met the search criteria as well as of systematic review articles (e.g., Foreman, Murphy, & Swerissen, 2006; Lidal, Huynh, & Biering-Sørensen, 2007; Shames, Treger, Ring, & Giaquinto, 2007; Steenstra, Verbeek, Heymans, & Bongers, 2005) located during the initial database search. References that were published no earlier than 1997 and that appeared relevant based on their title were then searched in the above-listed electronic databases. Those that were reported in English and for which the full text was accessible were then screened to determine if they met all search criteria necessary for inclusion in the critical review. This ancestry approach resulted in the discovery of an additional 10 articles worthy of review to help guide this RTW outcomes study. Finally, a journal search was conducted in attempt to locate relevant articles not identified during the database and ancestry searches. The following five journals were selected for review based on the prevalence of previously identified RTW research contained in these publications: *Journal of Occupational Rehabilitation*; *PAIN*; *Spine*; *Archives of Physical Medicine and Rehabilitation*; *Disability and Rehabilitation*. This journal search resulted in the detection of 10 more articles that met all search criteria and that were accordingly included in the critical review.

Data extraction and analysis.

The electronic and manual literature search described above resulted in the identification of 49 research studies that satisfied the inclusion criteria. The following information was extracted from each of these studies: population of interest; sample description; setting; research design; statistical analysis; independent variables; dependent variable(s); predictive model results. This information served as the basis for critically analyzing and synthesizing this selective sample of RTW literature. The critical review of these studies accordingly led to the identification of important literature gaps and helped establish the importance of this RTW outcomes study.

Population of interest.

Despite the selective literature search that was conducted, there remained significant methodological heterogeneity among the studies chosen for review. One source of this variation was with respect to the population being studied. This likely should come of little surprise given that work disability is a costly health outcome that is not confined to any particular health condition. Fortunately, the populations of interest in the studies identified in the literature search are similar to the population of interest for this RTW outcomes study in certain key respects (e.g., working-age individuals with injuries or illnesses that are commonly sustained or contracted on-the-job). Of the 49 studies that were critically reviewed, 45 focused on populations with a specific type of health condition. The majority (30) of these studies focused on health conditions that are common among injured employees. For example, 19 studies included samples of individuals with low back (including lumbar spine) conditions. There were nine studies that included samples of individuals who had been diagnosed with a musculoskeletal disorder (five), who were suffering from various back and/or neck conditions (two), or who had sustained orthopedic trauma (two). Another study included a sample of injured employees who had been diagnosed with carpal tunnel syndrome and who had undergone a carpal tunnel release as surgical treatment. In addition, one study was based on a sample of individuals who had been diagnosed with a work-related upper extremity disorder (including but not limited to carpal tunnel syndrome). There were 15 studies that included samples of individuals with various health conditions (i.e., seven with traumatic brain injury; four with spinal cord injury; one with major trauma; one with mild mental disorders; one with stroke; one with fibromyalgia) that are less common, but not absent, in workers' compensation settings. The four other studies that were critically reviewed included samples of individuals with miscellaneous health conditions.

Sample and setting.

Considerable variation among the 49 reviewed publications also existed in terms of study sample and setting. Regarding sample size, the studies can be categorized as follows: 10 studies with samples of 1,000 or more; 6 studies with samples between 500 and 999; 10 studies with samples between 250 and 499; 15 studies with samples between 100 and 249; 8 studies with samples of 99 or fewer.[17] Regarding setting, 18 studies were conducted in the United States and eight studies each were conducted in Canada and the Netherlands. Five studies were conducted in Australia and two studies each were conducted in Sweden, Switzerland, and Germany. One study each was conducted in the United Kingdom, Spain, Belgium, and Hong Kong. Additionally, the samples of 16 studies were derived from injured employees (or injured employee claims). The samples of the 33 other studies included individuals with various health conditions who were (or had been) on sick leave, receiving medical rehabilitation (inpatient or outpatient) services, enlisted in the military, or receiving VR services through a state-federal VR agency.

Research design and statistical analysis.

Less variation was found when comparing the research designs and statistical analyses of the studies included in the critical review. In fact, all of the studies used quantitative methods and correlational research designs. While the timeframes of a few studies were difficult to determine, approximately 32 studies used prospective designs (e.g., cohort studies) and 17 used retrospective designs (e.g., secondary data analysis). Additionally, *all* of the prospective studies

[17] These sample sizes are based on the original participants in a study and do not take into account possible attrition in studies in which follow-up data were collected.

were longitudinal (with follow-up periods ranging from one month to four years) whereas *most* of the retrospective studies were cross-sectional.[18] The statistical analyses that were employed in these studies included logistic regression, multiple regression, Cox proportional-hazards regression, discriminant analysis, and recursive partitioning analysis. A stepwise procedure was often used due to the lack of a logical or theoretical rationale regarding the relative contribution of various predictor variables (or sets of variables) to the prediction of RTW outcomes (e.g., Brouwers, Terluin, Tiemens, & Verhaak, 2009; Drake, Gray, Yoder, Pramuka, & Llewellyn, 2000; Laisné, Lecomte, & Corbiére, 2012; Leung & Man, 2005; Schade, Semmer, Main, Hora, & Boos, 1999; Schultz, Crook, Berkowitz, Milner, & Meloche, 2005; Schultz et al., 2002).

Independent variables.

The variables that were investigated as possible predictors of RTW outcomes were diverse in nature. This was anticipated given knowledge of prior systematic reviews of RTW literature which have consistently found that there is a wide range of work disability determinants (e.g., Foreman, Murphy, & Swerissen, 2006; Krause, Frank, Dasinger, Sullivan, & Sinclair, 2001; Turner, Franklin, & Turk, 2000). Though the array of variables found to be associated with RTW outcomes makes synthesis of this research difficult, it also makes clear that a multifactorial and biopsychosocial perspective is necessary in order to obtain a greater understanding of the RTW (and disablement) process. The variables most commonly found to be relevant predictors of RTW outcomes (or risk factors for work disability) can broadly be categorized into one of three factors: 1) medical; 2) individual; and 3) workplace. This categorization is in accordance with the WHO's ICF model as medical factors relate to an individual's health condition(s) and individual and workplace factors consist of contextual

[18] In total, nearly four out of five studies (about 39 out of 49) were longitudinal. The remaining studies (about 10 out of 49) were cross-sectional.

variables pertaining to a person and his or her work environment. Using this classification system, the RTW outcome predictors identified in the reviewed literature are discussed below.

Medical factors.

Injury-related characteristics. The severity of an individual's injury (and/or resulting impairment and functional limitation) was the medical factor that was most often found to be associated with RTW outcomes. Research strongly suggests that an inverse relationship exists between injury severity and employment status as more severely injured individuals (regardless of the health condition) tend to be less likely to be gainfully employed. This association has been demonstrated using a variety of measures of the severity of an individual's health condition. For example, in a study of individuals who had been hospitalized after suffering major trauma, Holtslag, Post, van der Werken, and Lindeman (2007) found that those with greater permanent physical impairment were less likely to be working at follow-up (i.e., an average of 15 months after injury). Studying a group of individuals with spinal cord injury, Krause, Sternberg, Maides, and Lottes (1998) found that those with paraplegia were more likely to RTW than those with quadriplegia. Additionally, there is evidence that a longer duration of complaints among a group of individuals sick-listed due to minor mental disorders (Brouwers et al., 2009) and a longer length of post-incident unconsciousness among a group of individuals with traumatic brain injury (Kreutzer et al., 2003) are associated with poorer RTW outcomes.

Several other studies have linked more subjective injury-related measures such as symptom severity (e.g., pain intensity, duration, frequency, and radiation) with RTW status (e.g., Dionne et al., 2005; Heymans et al., 2006; Iakova et al., 2012; Katz et al., 1997; van der Giezen, Bouter, & Nijhuis, 2000).[19] Similar results were obtained from a study conducted with a group of injured workers who had sustained an upper extremity disorder and who had not returned to their customary employment. The study's results indicated that self-report measures of functional limitations were able to effectively discriminate between those who had and who had not returned to modified duty (Feuerstein, Shaw, Lincoln, Miller, & Wood, 2003). Beyond the subjective complaints related to an injury or health condition under specific investigation, poorer RTW outcomes appear to be associated with evidence of preexisting conditions such as prior back surgery (Dionne et al., 2005) and previous sick leave (Linton & Halldén, 1998) and with the presence of co-morbidities (Pransky, Verma, Okurowski, & Webster, 2006). Holding to the relationship between injury (or overall health status) and RTW, a possible explanation is that injured individuals with other (prior or current) partially disabling health conditions may tend to have greater difficulty recovering and returning to their previously accustomed social roles such as remunerative employment.

Treatment-related characteristics. While treatment-related characteristics were not as prevalent as injury-related characteristics in the reviewed literature, there were nevertheless several methods used to assess their potential influence on RTW/employment status. Two studies (Dutta, Gervey, Chan, Chou, & Ditchman, 2008; Rogers, Bishop, & Crystal, 2005) investigated the relationship between type of VR services received and VR closure status (i.e., employed vs. not employed). Both found multiple VR services to be significantly associated with employment status, most notably receipt of job placement assistance (i.e., referral to a

[19] The subjective measures of an individual's perception of the severity of his or her symptoms and functional limitations arising from an injury undoubtedly include a psychosocial component. However, they are classified as injury-related characteristics (rather than individual psychosocial characteristics) by this researcher because they do not directly relate to an individual's thoughts and feelings regarding his or her interactions with a social (e.g., work) environment. Individual psychosocial characteristics thus include an individual's perception of the severity of his or her disability (i.e., the degree of discorrespondence between an individual and one or more social environments) but not of his or her symptoms or functional limitations.

specific job resulting in an interview). Regardless of the type of impairment, VR consumers receiving job placement were more likely to find and maintain employment for at least 90 days than those who did not receive this service. Focusing on medical rather than vocational rehabilitation, Steenstra et al. (2005) studied a group of health care professionals who were off work due to low back pain and found that those who were being treated by a specialist (rather than a general practitioner) and those who had sought care from an occupational physician (OP) were at higher risk for longer duration of sick leave. They postulated that the receipt of specialized care or the seeking of OP care may be indicative of more serious low back pain (i.e., increased injury/symptom severity).

Another important aspect of treatment, whether related to medical or vocational rehabilitation, is the timeliness in which it is received. For example, Blackwell, Leierer, Haupt, and Kampitsis (2003) found that the time from the date of injury to the date of VR referral was a significant determinant of whether injured employees in Montana returned to work. Specifically, injured employees referred for VR services within six months of their injury were 1.52 times more likely to RTW than those referred after six months. Pransky et al. (2006) obtained a similar finding in a workers' compensation context when assessing the relationship between the time from the date of injury to the date of nurse case manager (NCM) referral and an injured employee's length of disability. The authors found that delayed referral to NCMs, who help navigate injured employees through complex workers' compensation systems and coordinate their care, was significantly associated with prolonged disability. These results are consistent with earlier studies suggesting that early intervention (medically and vocationally) is an important factor in whether an injured employee is able to RTW (e.g., Gardner, 1991).

Individual factors.

Socio-demographic characteristics. Socio-demographic characteristics are frequently used to predict RTW outcomes likely because of their relative ease of access (e.g., available via administrative databases as well as patient self-report). The three socio-demographic characteristics that are most commonly assessed in relation to RTW are age, sex, and education.[20] While there is conflicting evidence about the strength of the association (and to a lesser extent the direction of the association) between each of these variables and RTW (particularly with respect to sex), it is generally agreed that age, sex, and education hold some predictive power in regards to employment-related outcomes. Of the reviewed literature that investigated these three socio-demographic characteristics, those with poorer RTW outcomes were typically *older* (e.g., Blackwell et al., 2003; Drake et al., 2000; Hackett, Glozier, Jan, & Lindley, 2012; Pransky et al., 2006; Shaw, Pransky, Patterson, & Winters, 2005), *female* (e.g., Brede, Mayer, & Gatchel, 2012; Feuerstein, Berkowitz, Haufler, Lopez, & Huang, 2001; Hansson, Hansson, & Jonsson, 2006; Mills, 2011; Pransky et al., 2006), and *less educated* (e.g., Hess, Ripley, McKinley, & Tewksbury, 2000; Krause et al., 1998; Murphy, Young, Brown, & King, 2003; Truchon et al., 2012; Walker, Marwitz, Kreutzer, Hart, & Novack, 2006).

There are multiple reasons that have been proposed for the general trends between these three socio-demographic variables and RTW. For example, it has been suggested that lower RTW rates among older workers may be a consequence of their increased likelihood of preexisting conditions, increased rate of co-morbidity, slower recovery, and competing

[20] According to the World Health Organization (2013), “male” and “female” are sex categories while “masculine” and “feminine” are gender categories. The distinction is that sex refers specifically to the biological and physiological characteristics that define men and women whereas gender refers to the socially constructed roles, behaviors, activities, and attributes considered appropriate for men and women. Though most authors of the studies that were critically reviewed used the term “gender”, this study will use the term “sex” as the intention is to make a distinction between males and females.

retirement options (Dasinger, Krause, Deegan, Brand, & Rudolph, 2000; Personick & Windau, 1995). A common assumption regarding the lower RTW rates of females is that the effects of an injury or illness may make it prohibitively difficult for women to continue to meet their domestic demands (e.g., child rearing; food preparing) *and* resume competitive employment (Lundberg & Frankenhaeuser, 1999). Less-educated workers are often employed in more physically-demanding occupations that offer lower levels of worker autonomy. Conversely, higher-educated workers will generally have more job opportunities than their less-educated counterparts should they be unable to return to their customary employment as a result of a health condition (Hess et al., 2000).

Other socio-demographic characteristics that are often studied include race, marital status, and residence. Regarding race, Rogers et al. (2005) found that white VR consumers were approximately 1.50 times more likely to maintain competitive employment for 90 days than non-whites. A comparable outcome was reached by Krause et al. (1998) who found that the odds of racial minorities (non-Caucasians) being gainfully employed were 2.80 times less than that of Caucasians among a group of individuals with spinal cord injury. Regarding marital status, study results (e.g., Kreutzer et al., 2003) have suggested that individuals who are married are more likely to RTW, possibly due to the social support that is offered from a marital partner (Foreman et al., 2006). Regarding residence, those living in urban rather than rural areas have been shown to be more likely to RTW (e.g., Fan, Foley, Rauser, Bonauto, & Silverstein, 2013; Hester, Decelles, & Gaddis, 1986).

Individual psychosocial characteristics. Individual psychosocial characteristics relate to one's thoughts and feelings regarding his or her interactions with a social (e.g., work) environment. These characteristics can be dichotomized according to whether they relate to an individual's cognitions or emotions.[21] An individual's expectations of his or her recovery (e.g., perceived ability to RTW) appear to be a major cognitive determinant of whether he or she actually achieves a successful RTW outcome. In particular, positive recovery expectations (e.g., expectation of being gainfully employed on a full-time basis within six months) have been shown to be associated with variants of desirable RTW outcomes such as a shorter duration of sick leave (Steenstra et al., 2005), first RTW (Clay, Newstead, Watson, & McClure, 2010), and sustained RTW (Heymans et al., 2006). Further evidence of the association between recovery expectations and RTW outcomes was obtained by Streibelt, Blume, Thren, Reneman, & Mueller-Fahrnow (2009) who found that expectations of disability (i.e., perception of the extent of limitations regarding long-term job performance due to health status) were an effective predictor of occupational participation one year after completion of inpatient rehabilitation among a group of individuals with varying degrees of work disability due to a musculoskeletal disorder.[22] An individual's perception of the severity of his or her disability and motivation to RTW also seem to be influential predictors of RTW outcomes. Studying two distinct groups of injured employees with low back conditions, Schultz et al. (2002) found RTW rates to be lower among those with higher degrees of self-reported disability while Pransky et al. (2006) found that low RTW motivation was predictive of prolonged work disability.

Another individual psychosocial characteristic that relates to cognition and that appears to be an important predictor of RTW outcomes is fear-avoidance beliefs. Studies have routinely

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[21] It is noteworthy that cognitive functions that are not psychosocial in nature have also been shown to be associated with RTW outcomes. For example, a study by O'Connell (2000) suggested that individuals with higher levels of intelligence (based on Performance IQ scores on the Wechsler Adult Intelligence Scale-R) and memory (based on Verbal Memory Index scores on the Wechsler Memory Scale-R) were more likely to RTW following a traumatic brain injury (relative to those with lower levels of intelligence and memory).

[22] In this study, occupational participation was two-pronged and was considered successful if an individual was employed at the 12-month follow-up *and* if he or she had been sick-listed for a period of six weeks or less because of his or her musculoskeletal disorder.

found that those with higher fear-avoidance beliefs have poorer RTW outcomes (e.g., den Boer, Oostendorp, Beems, Munneke, & Evers; 2006; Heymans et al., 2007; Heymans et al., 2009; Holden, Davidson, & Tam, 2010; Lindon & Halldén, 1998; Truchon et al., 2012; Wideman & Sullivan, 2011). This finding is consistent with the fear-avoidance model (Lethem, Slade, Troup &, Bentley, 1983) which offers an explanation as to why many individuals develop chronic musculoskeletal pain. The model suggests that injured individuals tend to avoid certain activities (e.g., work) because of fear of pain. When activity avoidance initially reduces (or does not increase) pain, this avoidant behavior is reinforced. Unfortunately, according to the model, this avoidant behavior often leads to a worsening of the patient's condition, a decrease in his or her functioning, and an increase in his or her disability.

Akin to fear-avoidance beliefs, locus of control seems to be an important cognitive contributor to the prediction of RTW outcomes. Locus of control refers to an individual's perception about the underlying central causes of events in his or her life (Rotter, 1966). While the construct is measured on a continuum, individuals are usually classified as possessing an internal (tendency to believe that one's behavior is guided by his or her personal decisions and efforts) or an external (tendency to believe that one's behavior is guided by external forces) locus of control. Prior research has suggested that individuals with an internal locus of control often have more positive work outcomes such as higher levels of job satisfaction (e.g., Lee, Ashford, & Bobko, 1990; Spector, 1982). Given the positive association between job satisfaction and RTW outcomes (as discussed below), it is reasonable to assume that individuals with an internal locus of control would be more likely to return to the labor force after being afflicted by a disabling health condition. This assumption is supported by the results of a study of fibromyalgia patients on sick leave who participated in a multidisciplinary pain management program (Torres et al., 2009). In the study, fibromyalgia patients who reported having a sense of permanent lack of influence over their pain (external health locus of control) were less likely to be employed at 12-month follow-up. Torres et al. (2009) proposed that those with an external health locus of control "may believe that their symptoms depend on factors beyond their control and even beyond the control of significant others (including physicians)" (p. 142). The authors also noted that individuals with an external health locus of control were less likely to be compliant with treatment (e.g., physical therapy; psychotherapy) which could also inhibit one's RTW capacity.

In addition to cognitions, an individual's emotions are also important determinants of his or her degree of disability after an injury or illness. As would be expected, research involving individuals with various health conditions has revealed that the presence of psychological distress has a negative influence on returning to work. This is evidenced by the results of multiple studies, including those of Brouwers et al. (2009) who found that individuals with minor mental disorders who reported higher levels of somatization and depression were less likely to RTW. These results were substantiated by Mngoma (2007) who found that injured workers who were experiencing non-specific low back pain and who participated in a RTW rehabilitation program were less likely to RTW if they reported higher levels of various psychological symptoms (including but not limited to somatization, anxiety, and depression). Also, an earlier study by Schade et al. (1999) found that higher levels of anxiety and depression were inversely related to being employed two years after lumbar discectomy surgery.

Workplace factors.

Workplace psychosocial characteristics. A related but distinct faction of psychosocial characteristics is comprised of variables that directly pertain to the relationship between a worker and the work environment. A literature review reveals that workplace characteristics have not received the same attention as worker (individual) characteristics regarding the relationship between psychosocial variables and RTW outcomes. However, there is growing recognition that the constellation of variables that influence work disability include psychosocial characteristics related to the workplace (e.g., Feuerstein et al., 2001; Sullivan, Feuerstein, Gatchel, Linton, & Pransky, 2005). Among the critically reviewed literature, the three workplace characteristics most often associated with RTW outcomes were attorney involvement, job satisfaction, and work support. Attorney involvement in a workers' compensation claim has consistently been found to be predictive of poorer RTW outcomes (Blackwell et al., 2003; Butterfield, Spencer, Redmond, Feldstein, & Perrin, 1998; Gumerman, 1998; Pransky et al., 2006). Though this relationship has proven reliable, the reason for this association is not clear. It may be that attorney involvement represents a strained relationship between the injured employee and his or her employer and/or that an adversarial environment creates a RTW barrier. Alternatively, attorney involvement may simply serve as a signal in that more seriously injured employees may be more likely to obtain legal representation. Whereas retaining an attorney is inversely related to RTW, job satisfaction has been shown to be positively associated with RTW (Heymans et al., 2009; Heymans et al., 2006). The relationship between job satisfaction and RTW has also been demonstrated by other studies which have found job tenure to be predictive of successful employment outcomes (Feuerstein et al., 2001; Pransky et al., 2006; Shaw et al., 2005). According to the Minnesota Theory of Work Adjustment (Dawis, England, & Lofquist, 1964), job satisfaction is a key determinant of job tenure. Thus, an injured employee with a positive employment experience would presumably be motivated to RTW given his or her level of attachment to the workplace. Finally, similar to job satisfaction, work support (i.e., social support in the workplace) was found to be positively related to RTW (Heymans et al., 2006; Laisné et al., 2012). This lends credence to Shaw, Pransky, and Fitzgerald's (2001) suggestion that injured employees who believe they have strong work support might be in a better position to overcome other RTW barriers relative to those without perceptions of such support.

Work-related characteristics. Work-related characteristics often overlap to some extent with workplace psychosocial characteristics in that they are typically measured via self-report and thus are often a reflection of a worker's perceptions of a situation. However, they differ in that they ideally represent more objective factors within a workplace. Perhaps the most common work-related characteristics are variants of the physical and psychological demands of a job. Butterfield et al. (1998), Feuerstein et al. (2001), and Shaw et al. (2005) each found that injured employees/military personnel with low back pain were less likely to achieve desirable work outcomes if employed in a physically demanding job. The findings of Schade et al. (1999) suggest that mental work demands may influence employment outcomes in a similar fashion as they found higher levels of occupational mental stress to be associated with lower RTW rates. This seems logical in that the residual abilities of injured or ill employees are less likely to be able to satisfy the requirements of demanding occupations. Another significant work-related characteristic identified in the literature is the regularity of a worker's schedule. Among a group of injured employees with low back pain, those with an irregular work schedule had a longer duration of disability (Truchon et al., 2012). An irregular work schedule can be construed as an additional work demand that injured employees may have difficultly meeting. One other work-related characteristic that has received attention in the literature is the availability of modified duty. Shaw et al. (2005) found that injured employees with low back pain who believed they would have access to modified work duty were 2.69 times more likely to be working one month after pain onset than those who did not believe they would have such access. This suggests that more flexible work environments (or at least the perception of such) encourage injured employees to remain on the job which may be particularly important given evidence that extended time away from the workplace is predictive of poorer RTW outcomes.

Dependent variable(s).

Though not as diverse as the sets of independent variables that were devised with its prediction in mind, the RTW criterion was also varied in terms of the way it was defined and/or measured. Likely attributable to its convenience, the most common method of measuring this outcome among the 49 studies that were critically reviewed was to assess study participants' RTW status at a specified time (e.g., 12 months after date of injury or onset of illness). However, as first pointed out by Baldwin, Johnson, and Butler (1996), this method has its limitations given the dynamic nature of the RTW (and disablement) process which often involves recurrences of work absence after an individual's initial labor market return following an injury or illness. In recognition of this methodological limitation, some authors used alternative measures of the RTW criterion. Eleven studies used duration of disability (i.e., work absence) as the primary RTW measure (e.g., Butterfield et al., 1998; Du Bois, Szpalski, & Donceel, 2009; Steenstra et al., 2005).[23] In these studies, the length of study participants' disability was discretely or continuously assessed according to the total number of missed work days (e.g., days of sick leave) or time loss days (e.g., temporary and total disability compensation days). Three of these studies (Heymans et al., 2009; Heymans, et al., 2006; Steenstra et al., 2005) also made distinctions between first (full RTW in own work or other work with equal

[23] Murphy and Young (2005) actually reversed this method by measuring work participation rate (number of months in employment post-injury divided by the number of months available for employment post-injury) rather than work absence rate in a continuous manner from the date of injury to the date of survey. Thus, in this instance, the outcome was technically a measure of duration of non-disability.

earnings for at least one day) and lasting (full RTW in own work or other work with equal earnings for at least four weeks) RTW. In the remaining studies, the RTW criterion included a discrete measure of work status at one or more specified times. Included among the studies was Kreutzer et al. (2003) who assessed the employment stability of individuals with a traumatic brain injury based on their work status at three follow-up intervals and Dionne et al. (2005) who developed an index of back-pain outcome (return to work in good health) that took into account work status, functional limitations, and number of days of work absence. Finally, there was some variation in terms of what constituted a successful outcome. Part-time employment status, for instance, was considered both successful (e.g., Dutta et al., 2008) and unsuccessful (e.g., Holtslag et al., 2007). Also, in some studies (e.g., Dawson, Levine, Schwartz, & Stuff, 2004; Sherer, Bergloff, High, & Nick, 1999; Watson, Booker, Moores, & Main, 2004), participation in education/training or volunteer work was considered a successful outcome (i.e., involved in a RTW process) even if an individual was not gainfully employed.

Predictive model results.

The performance of the predictive models that were designed to predict RTW outcomes of study participants was largely assessed with respect to model fitness (i.e., goodness-of-fit) and accuracy (i.e., clinical usefulness). These two characteristics of a predictive model were typically evaluated with one or a combination of three measures. The first was the coefficient of determination (R^2) or one of its analogs (e.g., Nagelkerke R^2), varying in accordance with the statistical technique employed. The coefficient of determination and its analogs are more global measures of fit that approximate the proportion of variance in the outcome that is explained by a model (Cook, 2007). The second was a concordance statistic (i.e., *c*-statistic) which represents the area under the receiver operating characteristic (ROC) curve and is a measure of a model's ability to accurately discriminate between study participants who do and who do not achieve (or possess) the outcome of interest (e.g., RTW versus no RTW) (Hosmer, Lemeshow, & Sturdivant, 2013, p. 174). The third was a correct classification rate which specifies a model's accuracy in predicting the level of outcome study participants will actually attain at some point in the future.

The diversity regarding the populations studied and the methods employed (including RTW definitions and follow-up times) in the critically reviewed research makes direct comparison of predictive model results difficult. General trends can nevertheless be discovered when examining the results of a compilation of RTW outcome studies. The median explained variance of the RTW predictor models found in the 49 studies included in this literature review was 27% while the interquartile range was 19.5% (18.0% to 37.5%). This is consistent with previous reviews of studies which found that 20% to 40% of the variance in RTW rates could be explained (Pransky et al., 2006). The *c* statistics that were identified had a median value of .745 and an interquartile range of .068 (.695 to .763). With the typical range of *c* statistics being .50 (no discrimination) to 1.00 (perfect discrimination) and values of .70 to .80 representing "acceptable" discrimination (Hosmer et al., 2013, p. 177), this suggests that the tendency is for predictive models of RTW outcomes to have a moderate degree of discriminant ability. Lastly, the median overall correct classification rate (i.e., considering sensitivity and specificity) was 72.9% and the interquartile range was 8.6% (68.9% to 77.5%). Thus, on average, previously developed models (which have included various combinations of medical, individual, and workplace factors) have demonstrated the ability to accurately predict whether an injured or ill individual will RTW nearly three-fourths of the time.

Summary

A review of workers' compensation systems in the United States (including the system in Minnesota) reveals that there is a continued tendency to equate impairment with disability. Such an approach is more consistent with a biomedical rather than a biopsychosocial perspective of disability and appears to inadequately account for individual and workplace (i.e., contextual) factors that contribute to an individual's residual ability to work following an injury or illness. The enduring reliance on a biomedical perspective of disability among many workers' compensation systems is likely because of its relative simplicity given the inherent complexity associated with assessing the construct's multiple and interactive factors. It is fortunate that there is a growing body of research accumulating evidence on factors that are predictive of work disability (as measured by RTW outcome variants). Despite the significant methodological heterogeneity and limitations present in the studies that comprise this research (perhaps most notably with respect to the varying definitions of RTW), general trends regarding work disability risk factors have developed. For example, workers who are at higher risk of prolonged (including permanent) disability tend to be older, non-white, single, less-educated, and female. Among other characteristics, they also tend to have more permanent impairment, lower expectations of recovery, and shorter job tenure. This knowledge is essential to the determination of work disability and should be used when assessing RTW (or rehabilitation) potential in any disability compensation system.

This RTW outcomes study contributes to rehabilitation research by considering the main and (first-order) interaction effects of a range of variables believed to be associated with work disability. This study is particularly relevant given that it assessed the impact of variables that are available to qualified rehabilitation consultants in Minnesota tasked with determining which injured employees are capable of returning to work with receipt of VR services. The intrinsically subjective decision-making process currently being employed in Minnesota's workers' compensation system would be greatly enhanced by the development of a precise and accurate predictive model of RTW potential. Though predictive models of this kind do exist (to varying levels of precision and accuracy), a review of RTW literature found no evidence that these models were derived from data about injured employees in Minnesota. Developing a predictive model of RTW potential that is tailored to injured Minnesota employees seems to be a worthy endeavor given the decline in the RTW rates of VR participants in Minnesota's workers' compensation system in recent years (71.5% in 1998 to 54.5% in 2011). Depending on its performance, such a model could be valuable in discriminating between injured employees who are and who are not likely to RTW after receipt of VR services. A model with strong predictive power could also improve the efficient allocation of VR services and lead to informed decisions about service provision suitable to all disability stakeholders involved.

Chapter 3: Methodology

Introduction

In this chapter the research design and the specific procedures used to conduct this RTW outcomes study are described. Several research methods were undertaken in developing and validating a predictive model of the RTW potential of injured employees in Minnesota's workers' compensation system who sustained permanent impairment and who received VR services. Each of these methods, along with a discussion of study limitations, is detailed in separate sections of this chapter. These sections include the following: research design; target and accessible population; data collection procedures; variable description; data analysis; adequacy of dataset size; methodological limitations.

Research Design

This study was designed to evaluate the extent to which a set of medical, individual, and workplace factors contribute to a predictive model of the RTW status at claim closure of injured employees in Minnesota who sustained permanent impairment attributable to their work-related injury and who received VR services. To accomplish this research purpose, a closed-claim, retrospective design was implemented. The accessible population included all injured employee indemnity claims that were included in the statewide workers' compensation claims database maintained by the Minnesota Department of Labor and Industry (DLI) in St. Paul, that were filed between January 1, 2003 and December 31, 2011, that were closed as of September 30, 2012, and that satisfied all other eligibility criteria (e.g., evidence of a permanent impairment; receipt of VR services). The secondary data (which were classified as "summary data"[24]) used in this retrospective study were de-identified via coding procedures by Mr. Brian Zaidman, a senior research analyst with the Minnesota DLI, prior to this researcher's procurement of data access.

A retrospective, correlational research design was used for this study because it allowed for an investigation of the antecedent factors associated with RTW outcomes that are already known. This *ex-post facto* study was cross-sectional as relevant information was collected from each injured employee claim at one point in time. A major advantage of this study design was that a predictive model could be developed and validated based on reliable data that was easily accessible and that pertained to a large number of claims of injured employees who sustained permanent impairment and who received VR services in Minnesota's workers' compensation system. Another strength of this correlational research study was that it allowed for the analysis of objective data available to qualified rehabilitation professionals tasked with determining an injured employee's rehabilitation potential following a work-related incident. The use of this study design also made possible the identification of the relative importance of each independent variable in predicting the RTW status of injured employees as of claim closure.

Though using a non-experimental research strategy restricts a researcher's ability to reveal causal relationships, discovering associations between RTW predictors and the outcome (both individually and collectively) among the accessible population was sufficient to yield meaningful results. Additionally, after-the-fact observation of relationships between RTW

[24] Summary data are defined as "statistical records and reports derived from data on individuals but in which individuals are not identified and from which neither their identities nor any other characteristic that could uniquely identify an individual is ascertainable" (Minnesota Statues 2013, section 13.02, subdivision 19). In accordance with this definition, the Institutional Review Board (IRB) at Virginia Commonwealth University determined that this research study qualified for exemption according to 45 CFR 46.101(b), category 4.

predictors and the outcome yielded information on data collected from claims of injured employees whose participation in Minnesota's workers' compensation system was not influenced by researcher manipulation. This was critical to preserving the study's (potential) external validity and to ensuring that conclusions could be generalized to the target population.

Target and Accessible Population

The target population of this outcomes study was injured employees in Minnesota who have sustained permanent impairment attributable to a work-related incident and who have subsequently received VR services to aid their RTW efforts (This study may also have implications for injured employees throughout the United States who share these characteristics.). The accessible population consisted of injured employee claims that were in the Minnesota workers' compensation claims database and that met the following eligibility criteria: 1) claims of injured employees filed between January 1, 2003 and December 31, 2011; 2) claims of injured employees who likely sustained some degree of permanent impairment attributable to their work-related incident;[25] 3) claims of injured employees who received VR services to help them RTW (and thus who presumably possessed some rehabilitation potential); 4) claims of injured employees with no missing data regarding the variables of interest to this study;[26] 5) claims of injured employees who were between the ages of 18 and 64 as of the date of injury; 6) claims of injured employees who resided in Minnesota; 7) claims of injured employees

[25] This included the following three types of injured employee claims: 1) claims in which a PPD benefit was paid and stipulated to by the employee and employer; 2) claims in which a PPD benefit was paid but was not stipulated to by either the employee or employer; and 3) claims in which no PPD benefit was technically paid but that involved a claim settlement of at least $20,000 that likely included consideration of a compromised PPD award (B. Zaidman, personal communication, March 13, 2013).

[26] The one exception to this eligibility criterion was with respect to the severity of permanent impairment predictor as the workers' compensation claims database did not include a permanent impairment rating assigned by a treating or evaluation physician for claims in which no PPD benefit was paid (despite there likely being a compromised PPD award). Claims without data regarding the severity of permanent impairment but that met all other eligibility criteria and in which the injured employee received a compromised PPD award were thus also included in this study.

whose VR benefit was discontinued due to VR plan closure and/or claim settlement (i.e., not due to the injured employee being dead or missing or due to the withdrawal of the qualified rehabilitation consultant); and 8) claims of injured employees closed by September 30, 2012. Rather than taking a sample of relevant claims, the entire accessible population was used to conduct the study. It was anticipated that the inclusion of all injured employee claims that met the eligibility criteria would ensure that this study's results could be generalized to the broader target population.

Guided by the eligibility criteria discussed above, this study's full dataset was extracted from the Minnesota workers' compensation claims database by Mr. Zaidman of Minnesota's DLI in February 2013. Application of the first eligibility criterion (i.e., claims of injured employees that were filed between 2003 and 2011) resulted in a total of 214,122 claims. Of these claims, 60,930 were filed by injured employees who had evidence of sustaining permanent impairment as a result of their work-related incident. Claims of injured employees that met the first two eligibility criteria but in which VR services were not provided were then excluded. At this stage of dataset extraction, there were 27,566 remaining claims. Claims with missing data regarding the variables of interest were then eliminated (with the notable exception of the severity of permanent impairment predictor), resulting in 17,616 residual claims. Finally, claims of injured employees were excluded for those who were not members of the working-age population (i.e., those not between the ages of 18 and 64), who resided outside of Minnesota, whose VR benefit was discontinued due to the injured employee being dead or missing or due to the withdrawal of the qualified rehabilitation consultant, and/or whose claim was not closed by September 30, 2012. After application of these eligibility criteria, 15,372 claims remained.

These 15,372 claims of injured Minnesota employees constituted this study's accessible population and all were included in this RTW outcomes study.

Data Collection Procedures

This study's data source was the Minnesota workers' compensation claims database that is maintained by the Minnesota DLI. This database is set up in relational tables and contains all indemnity claims filed since 1983. The claims information that is entered into the database's fields is obtained from various workers' compensation forms that are submitted to the DLI by insurers, attorneys, and qualified rehabilitation consultants. The workers' compensation forms from which data about the variables of interest for this study were collected include the following: First Report of Injury; Notice of Insurer's Primary Liability Determination; Notice of Benefit Payment; Notice of Intention to Discontinue Workers' Compensation Benefits; R-2 Rehabilitation Plan; R-8 Notice of Rehabilitation Plan Closure; Health Care Provider Report.[27] Information is extracted from these forms and entered into the database primarily by data entry staff members within the workers' compensation division of Minnesota's DLI. Data entry records are then sampled and checked by other staff members according to an established quality control methodology (B. Zaidman, personal communication, January 24, 2013).

Relying upon an existing data source is advantageous for several reasons. The most salient benefit of this secondary data analysis was that it was much more economical than collection of primary data which would have been exorbitantly time consuming and expensive. Moreover, this study was absent of problems stemming from subjects' awareness of, and reaction to, research participation (e.g., Hawthorne effect). This study was also relatively free of reliability concerns that often accompany intrinsically subjective self-report measures (e.g., an

[27] These workers' compensation forms are available on the Minnesota Department of Labor and Industry website at the following link: http://www.dli.mn.gov/wc/wcforms.asp

injured employee's RTW motivation). Any effects of subject cooperation and attrition on this retrospective study's internal validity were likely minimal as well (e.g., few injured employees go missing or die prior to the closure of their workers' compensation claim). An additional benefit of this data collection plan was that it almost certainly resulted in the receipt of accurate data given the data verification measures taken by staff members within the workers' compensation division of Minnesota's DLI. An important consequence of having access to an existing data source such as Minnesota's workers' compensation claims database is the ability to collect a large amount of data. Specifically, the ability to use the entire accessible population of claims of injured employees who sustained permanent impairment and who received VR services (and who met all other designated criteria) improved this study's rigor by increasing its statistical power and enhancing the generalizability of its results.

Variable Description

Variables selected for inclusion in this study were based on the results of a critical literature review in combination with researcher judgment about medical, individual, and workplace factors that may influence an injured employee's RTW potential. Though results of previous rehabilitation research served as a guide to this study, the selection of predictor variables was also dependent on what information was available from the Minnesota workers' compensation administrative claims database. Additionally, as a prerequisite for data access, all data were de-identified and were consequently discrete in nature. Each of this study's categorical independent variables (predictors) and its dependent variable (outcome) are presented in Table 1. Descriptions of each variable (including the coding scheme for each variable) are also provided below.

Table 1

Independent and Dependent Variables

<u>Independent Variables</u>

Medical Factors
- Nature of Injury or Illness
- Part of Body Affected
- Severity of Permanent Impairment
- Time from Date of Injury to VR Service Initiation
- Pre-Existing Claim Status

Individual Factors
- Age
- Sex
- Education
- Marital Status
- Residence

Workplace Factors
- Job Tenure
- Pre-Injury Average Weekly Wage
- Attorney Involvement
- Pre-Injury Occupation
- Pre-Injury Industry

<u>Dependent Variable</u>

Rehabilitation Outcome
- RTW Status as of Claim Closure

Independent variables.

***Medical factors*.**

Nature of injury or illness.

The principal physical characteristic(s) of a work-related injury or illness. Research analysts with Minnesota's DLI classify the nature of an injury or illness sustained by an employee using the coding structure outlined in the U.S. Bureau of Labor Statistics' Occupational Injury and Illness Classification System (OIICS) manual (BLS, 2012). This coding structure includes the following nine major divisions: traumatic injuries and disorders; systemic diseases and disorders; infections and parasitic diseases; neoplasms, tumors, and cancers; symptoms, signs, and ill-defined conditions; other diseases, conditions, and disorders; exposures to disease – no illness incurred; multiple diseases, conditions and disorders; non-classifiable. For this study, this coding structure was adapted to maximize the representativeness of common work-related injuries and illnesses. In particular, an emphasis was placed on traumatic injuries and disorders which are generally the result of a single incident, event, or exposure over the course of a single work shift and which account for more than 93% of nonfatal occupational injuries and illnesses involving days away from the workplace (Northwood, Sygnatur, & Windau, 2012, p. 6-7). After adaptation of the OIICS coding structure, this variable included six categories and was coded as follows: traumatic injuries to bones, nerves, spinal cord (e.g., fractures) (0); traumatic injuries to muscles, tendons, ligaments, joints (e.g., sprains, strains, and tears) (1); wounds, bruises, and burns (e.g., amputations; avulsions) (2); non-specified pain-related conditions (e.g., low back pain) (3); multiple traumatic injuries and disorders (4); other and non-classifiable injuries or illnesses (e.g., carpal tunnel syndrome; intracranial injuries; crushing injuries; coal workers' pneumoconiosis) (5).

Part of body affected.

The part(s) of the body directly affected by a work-related injury or illness. Similar to the nature of injury or illness variable, research analysts with Minnesota's DLI classify the part(s) of an injured employee's body affected by a work-related injury or illness using the coding structure outlined in the U.S. Bureau of Labor Statistics' OIICS manual (BLS, 2012). This coding structure includes the following nine major divisions: head; neck (including throat); trunk; upper extremities; lower extremities; body systems; multiple body parts; other body parts;

non-classifiable. For this study, claims of injured employees with head and neck (including throat) injuries were combined. Claims of injured employees with trunk and body system injuries were also combined. In addition, a distinct category for back and/or spine injuries was created. Lastly, there were no claims of injured employees with injuries to other body parts or with non-classifiable injuries. As a result, this variable included six categories and was coded as follows: head and neck, including throat (0); trunk and body systems (1); upper extremities (2); lower extremities (3); back (including spine and spinal cord) (4); multiple body parts (5).

Severity of permanent impairment.

The severity of permanent impairment sustained by an injured employee (after reaching maximum medical improvement) that is deemed attributable to his or her work-related incident. An injured employee's permanent impairment rating represents the percentage of impairment to his or her whole body and is assigned by a treating or evaluating physician in accordance with the Minnesota workers' compensation PPD schedules. This variable included six categories and was coded as follows: 1% to 5% (0); 6% to 10% (1); 11% to 15% (2); 16% to 20% (3); 21% or more (4); unknown (5).

Time from date of injury to VR service initiation.

Length of time (measured in months) from an injured employee's date of injury to his or her VR service initiation. This variable included five categories and was coded as follows: 3 months or less (0); between 3 and 6 months (1); between 6 and 12 months (2); between 12 and 18 months (3); 18 months or more (4).

Pre-existing claim status.

An injured employee's prior workers' compensation claim status. This binary variable was coded as follows: one or more prior workers' compensation claims (0); no prior workers' compensation claim (1).

***Individual factors*.**

Age.

Chronological age of an injured employee as of the date of injury. All injured employees included in the study were members of the working-age population (18 to 64 years) and were divided into customary age groups (i.e., 25 to 34 years; 35 to 44 years; 45 to 54 years; 55 to 64 years) (e.g., U.S. Department of Commerce, 2012b). Younger working-age injured employees (i.e., 18 to 24 years) were classified into a distinct group as well. Using this age classification method, this variable included five categories and was coded as follows: 18 to 24 years (0); 25 to 34 years (1); 35 to 44 years (2); 45 to 54 years (3); 55 to 64 years (4).

Sex.

Self-identification of an injured employee as male or female. This binary variable was coded as follows: male (0); female (1).

Education.

Highest level of education obtained by an injured employee as of the date of injury. This variable included five categories and was coded as follows: less than high school (0); high school or general equivalency diploma (1); some post-secondary courses but no degree (2); post-secondary vocational/technical program (3); bachelor's degree or higher (4).

Marital status.

Marital status of an injured employee as of the date of injury. This binary variable was coded as follows: married (0); not married (1).

Residence.

Place of residence of an injured employee as of the date of injury. This variable was used to distinguish between injured employees who reside inside and outside of a metropolitan statistical area (MSA). MSAs in Minnesota include the following: Duluth, MN-WI; Fargo, ND-MN; Grand Forks, ND-MN; LaCrosse, WI-MN; Mankato-North Mankato, MN; Minneapolis-St. Paul-Bloomington, MN-WI; Rochester, MN; St. Cloud, MN. This binary variable was coded as follows: metropolitan (0); non-metropolitan (1).

***Workplace factors*.**

Job tenure.

Length of employment of an injured employee with his or her employer as of the date of injury. This variable included three categories and was coded as follows: less than 1 year (0); 1 to 5 years (1); more than 5 years (2).

Pre-injury average weekly wage (AWW).

An injured employee's AWW in his or her occupation as of the date of injury. This variable included four categories and was coded as follows: $500 or less (0); $501 to $750 (1); $751 to $1,000 (2); $1,001 or more (3).

Attorney involvement.

An injured employee's legal representation status regarding his or her workers' compensation claim. This binary variable was coded as follows: attorney involved (0); no attorney involved (1).[28]

Pre-injury occupation.

Occupation of an injured employee as of the date of injury. Research analysts with Minnesota's DLI classify an injured employee's occupation into one of 22 major occupational groups (excluding military specific occupations) according to the U.S. Bureau of Labor Statistics' Standard Occupational Classification (SOC) system (BLS, 2010). These 22 major occupational groups are often aggregated into the following 10 occupational groups: management, business, and financial operations; professional and related (including computer, engineering, and science; education, legal, community service, arts, and media; healthcare practitioners and technical); service; sales and related; office and administrative support; farming, fishing, and forestry; construction trades and related; installation, maintenance, and repair; production; transportation and material moving. For this study, to ensure that enough cases were in each occupational group, an injured employee's pre-injury occupation was further distinguished according to whether it was blue-collar work (including farming, fishing, and forestry; construction; installation, maintenance, and repair; production; transportation and material moving), white-collar work (including management, business, and financial operations; professional and related; office and administrative support) or pink-collar work (including

[28] Attorney involvement was classified as a workplace (rather than an individual) factor in this study based on the assumption that this variable may be a useful gauge of the injured employee's relationship with his or her pre-injury employer. Given findings from the literature review (e.g., Blackwell et al., 2003), it was presumed that attorney involvement in a workers' compensation claim may serve as a contextual barrier to successful RTW.

service; sales and related). This variable thus included three categories and was coded as follows: blue-collar work (0); white-collar work (1); pink-collar work (2).

Pre-injury industry.

Industry in which an injured employee worked as of the date of injury. Research analysts with Minnesota's DLI classify an injured employee's industry into one of 20 aggregate industrial groups according to the U.S. Census Bureau's North American Industrial Classification System (U.S. Department of Commerce, 2012a). For this study, the industry in which an injured employee worked was further aggregated into 11 industrial groups that were coded as follows: natural resources and mining (0); construction (1); manufacturing (2); trade, transportation, and utilities (3); information (4); financial activities (5); professional and business services (6); education and health services (7); leisure and hospitality (8); other services (9); public administration (10).

Dependent variable.

Rehabilitation outcome.

RTW status as of claim closure.

Employment status of an injured employee at the time of claim closure. This binary variable was coded as follows: RTW (0); no RTW (1). Injured employees coded as "RTW" (i.e., employed) could therefore have been working full-time, part-time, or on modified duty at the time of their claim closure.

Data Analysis

Data analysis was performed using IBM SPSS Statistics V21.0 and included descriptive and predictive analyses. The intent to develop and validate a prognostic model of RTW outcomes dictated that predictive analysis was the focus of this study. However, univariate and bivariate descriptive analyses served important purposes. The primary purpose of univariate analysis was to describe the study's accessible population according to the variables of interest. The accessible population (i.e., all injured employee claims that were in the Minnesota workers' compensation claims database and that met each eligibility criterion) was described with frequency and relative frequency distributions given the categorical nature of each of the predictors as well as the outcome. Bivariate analysis was used to assess the relationships between study variables. Of particular importance was the magnitude of variable associations.[29] The magnitude of associations between study variables was evaluated using Cramér's *V* coefficient (φ_c). This coefficient is a useful measure of the strength of the relationship between categorical variables as it is based on the chi-square statistic and is generalizable across contingency tables of varying sizes. Values of the Cramér's *V* coefficient range from .00 to 1.00 with higher values indicating a stronger association between variables (Polit & Beck, 2008, p. 602). The magnitude of relationships between study variables was characterized according to the following qualitative descriptors (with the value range of φ_c in parentheses): 1) negligible association (.00 and under .10); 2) weak association (.10 and under .20); 3) moderate association (.20 and under .40); 4) relatively strong association (.40 and under .60); 5) strong association (.60 and under .80); and 6) very strong association (.80 to 1.00) (Rea & Parker, 1992, p. 203). In addition to the use of these descriptors, bivariate analysis results were displayed using a two-dimensional correlation matrix and contingency tables. These results were particularly important in revealing whether any vulnerable populations (e.g., less-educated workers) were achieving poorer RTW outcomes relative to the general population of injured Minnesota employees.

[29] Significance and direction are two other fundamental dimensions of variable associations. Significance was given particular focus during model building and testing in this study's predictive analysis. Direction, on the other hand, was of less relevance to this study's descriptive and predictive analyses because of the use of categorical variables (many of which were nominal).

Predictive analysis was performed using binary logistic regression to establish the extent of the relationship between the outcome and the set of predictors. Logistic regression was well suited as a statistical technique for this study as it allows for the prediction of a discrete outcome (e.g., RTW status as of claim closure) from multiple independent variables that may be continuous, discrete, dichotomous, or a mix (Tabachnick & Fidell, 2007, p. 437). Two types of logistic regression, standard and stepwise, were implemented as part of this predictive analysis. Standard logistic regression was initially employed to evaluate the independent and collective contribution of the full set of predictors (including a full set of main and first-order interaction effects and a full set of main effects only) to the explanation of the RTW status as of claim closure of the study's accessible population. Backward stepwise logistic regression was then used to determine whether the full model(s) could be simplified without relinquishing predictive power. However, prior to the implementation of these logistic regression techniques, the accessible population was randomly split into two groups in order to allow for an evaluation of the optimal predictive model's internal validity.[30] That is, the full dataset was randomly divided into a development and a validation dataset of approximately equal sizes. Through the use of standard and [backward] stepwise logistic regression procedures, the most parsimonious predictive model (i.e., the optimal RTW model) that remained capable of precisely and accurately predicting the RTW status as of claim closure of injured employees whose claims comprised the development dataset was identified. After assessment of the optimal RTW model's specification and performance, it was applied to the validation dataset. At this point, the

[30] The full dataset was randomly split by Mr. Zaidman of Minnesota's DLI prior to this researcher's data receipt. Mr. Zaidman split the dataset using IBM SPSS Statistics V19.0 by assigning each case a random value from 1 to 20,000 and then splitting them approximately in half (i.e., coding cases assigned a value from 1 to 10,000 with a 1 and coding cases assigned a value from above 10,000 to 20,000 with a 2) (Brian Zaidman, personal communication, March 20, 2013).

relationship between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes was determined. The optimal RTW model's internal validity was then assessed by comparing its performance (particularly its classification accuracy) when applied to the split datasets.

Logistic regression is convenient given its less restrictive assumptions regarding the distribution of predictors relative to other statistical techniques (e.g., multiple regression) used to estimate the relationships among variables (Polit & Beck, 2008, p. 629). Nevertheless, there were some practical issues that had to be addressed. According to Tabachnick and Fidell (2007, p. 496), these issues related to the following: 1) ratio of cases to variables and missing data; 2) adequacy of expected frequencies and power; 3) linearity in the logit; 4) multicollinearity; 5) outliers in the solution; and 6) independence of errors. An investigation of the extent to which these issues could have posed threats to the quality of this study, including the identification of methods for evaluating and resolving any problems that could have arisen, was warranted.[31] The following paragraph includes a brief discussion of each of these potential limitations to this predictive analysis.

First, regarding the ratio of cases to variables, a minimum recommendation is that a study should have at least 10 outcome events per variable (EPV) in order to avoid common problems with small datasets such as high variability (as evidenced by large parameter estimates and standard errors) and low statistical power (e.g., Harrell, Lee, Califf, Pryor, & Rosati, 1984; Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996). With 4,762 events (RTW as of claim closure) and 2,886 non-events (no RTW as of claim closure) in the development dataset (and with 4,812 events and 2,912 non-events in the validation dataset), along with 49 predictors in the

[31] This investigation was performed when deriving the optimal RTW model from the development dataset.

optimal RTW model, problems associated with having too few cases were not a concern. Likewise, missing data was not a concern as listwise case deletion was implemented given access to a large dataset (again with the exception of the severity of permanent impairment predictor). Second, expected cell frequencies were checked to determine if they were too small (i.e., if any were less than one or if more than 20% were less than five) for obtaining interpretable goodness-of-fit test results. Fortunately, as no expected cell frequencies were this small, no adjustments such as collapsing categories for variables with more than two levels had to be made. Third, though it is assumed when using logistic regression that there is a linear relationship between continuous predictors and the logit transform of the outcome, this posed no potential problem for this study as all predictors were categorical. Additionally, logistic regression requires no assumptions about linear relationships among the predictors themselves (Tabachnick & Fidell, 2007, p. 443). Fourth, because logistic regression is sensitive to extremely high correlations among independent variables, redundant predictors (i.e., predictors with a bivariate correlation of 0.90 or higher) were not included in this predictive analysis. Fifth, a residuals analysis was performed to detect and describe outliers (i.e., cases having standardized residuals with an absolute value greater than three). Upon examination, it was discovered that no cases possessed residuals of this magnitude. Thus, it was concluded that there was an absence of outliers in the solution. Sixth, the assumption of independence of errors when conducting a logistic regression analysis was met as information was obtained from separate claims of injured Minnesota employees who sustained permanent impairment and received VR services. In this respect, the cases were unrelated to one another (i.e., there were no repeated measures).

This study's predictive analysis was performed in order to answer five research questions by testing their associated hypotheses. These research questions and hypotheses, along with a description of the methods used to address them, are provided below:

Model development.

- Research question 1: Does knowledge of the full set of RTW outcome predictor variables make a difference in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 1: Knowledge of the full set of RTW outcome predictor variables does make a difference (i.e., is helpful) in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

This initial research question asked whether the predictor variables, taken in combination, contributed to the prediction of the outcome. Answering this question required comparison of a constant-only model with a model that had the constant plus all predictors (Tabachnick & Fidell, 2007, p. 458). For this study, a constant-only model was compared with two models: a model that had the constant plus all main effects and a model that had the constant plus all main *and* first-order interaction effects. The hypotheses that the full sets of RTW outcome predictor variables (i.e., the full main effects only model and the full main and first-order interaction effects model) did contribute to the prediction of the outcome was assumed to be true if a statistically significant difference between the full models and the constant-only model was obtained at a level of $p < .05$. Such a result would suggest that the null hypothesis of no association between the predictors and the outcome could be rejected.

- Research question 2: Can a more parsimonious RTW model be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 2: A reduced RTW model can be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

Using stepwise logistic regression with backward elimination, a reduced model was developed by deleting predictor variables that did not significantly contribute to prediction of the outcome. When using stepwise procedures such as backward elimination, Hosmer, Lemeshow, & Sturdivant (2013, p. 126) recommend a criterion for variable inclusion that is less rigorous than .05. Specifically, they recommend that a *p*-value ranging from .15 to .20 be used to reduce the risk that important predictors are removed from the model. The Akaike Information Criterion (AIC) has an associated *p*-value of .157 and is often used for variable selection in models as it possesses good theoretical and statistical properties (Steyerberg, Eijkemans, & Habbema, 1999; Steyerberg, 2010). The AIC was the initial "alpha" level used to determine variable retention in this analysis. Given access to a large dataset, more stringent alpha levels were then applied (e.g., *p*-value of .05) to determine whether a further reduced model could be developed without surrendering predictive capacity. During variable selection, all reduced models (including main effects only and/or main and first-order interaction effects) were compared with the full models. The hypothesis that the full and reduced models would not be reliably different in their predictive capacity was assumed to be true if the reduced model(s) remained statistically significantly different from the constant-only model *and* if model performance measures were similar (e.g., overall classification rates of full and reduced models within about 5% of one another). Variable selection was completed when the most parsimonious model that was not reliably different from the full models in its ability to predict this study's outcome was identified.

- Research question 3: How well does the optimal RTW model (i.e., the most parsimonious model that reliably predicts the outcome) fit observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 3: Predicted RTW outcomes from the optimal RTW model are not significantly different from observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

This research question allowed for testing of the goodness-of-fit of the optimal RTW model. The two primary components of a model's fitness, and ultimately its accuracy, are calibration and discrimination. Calibration refers to the agreement between a model's predicted probabilities and the observed outcomes (Cook, 2007, p. 928). A well calibrated model is thus one that generates predictions (e.g., predicted risk of an injured employee failing to RTW) that closely resemble actual outcomes. For this study, the inferential test that was used to assess the calibration of the optimal RTW model (i.e., to test the model's predicted RTW outcomes relative to observed RTW outcomes) was the Hosmer-Lemeshow (H-L) test (Hosmer and Lemeshow, 1980). This widely used test, which produces a Pearson chi-square statistic, suggests that a model fits data well when a statistically insignificant result (i.e., $p > .05$) is obtained. The hypothesis would thus be supported by a non-significant chi-square at a level of $p > .05$.

It is noteworthy that the H-L test is recognized as an imperfect measure of model calibration as it is sensitive to large sample sizes (particularly when *n* significantly exceeds 1,000) (Kramer & Zimmerman, 2007). Given this study's large dataset (even after splitting the dataset), additional information was used to assess the optimal RTW model's calibration, including an evaluation of deciles-of-risk statistics and performance of a linear regression of predicted and observed decile means. If the model calibrated well, the predicted and observed frequencies within each decile of risk of failure to RTW as of claim closure would be similar for both outcome groups (i.e., claims of injured employees who did and who did not RTW as of claim closure) (Tabachnick & Fidell, 2007). In addition, when regressing predicted and observed decile means, satisfactory model calibration would be indicated by a slope that was not significantly different from one and an intercept term that was not statistically significantly different from zero (Kramer & Zimmerman, 2007).

Discrimination refers to a model's ability to distinguish between those who do and do not have the outcome of interest (RTW status as of claim closure in this study) (Cook, 2007, p. 928). A model's discriminant ability is usually quantified by the *c* statistic, also known as the area under the ROC curve (AUC). *C* statistics typically range from .50 (no discrimination) to 1.00 (perfect discrimination). Higher *c* statistics signal greater discriminant ability. For *c* statistics between 0.5 and 1.0, Hosmer et al. (2013, p. 177) offer the following general guidelines: 1) $.50 < \text{AUC} < .70$ represents "poor" discrimination; 2) $.70 \leq \text{AUC} < .80$ represents "acceptable" discrimination; 3) $.80 \leq .90$ represents "excellent" discrimination; and 4) $.90 \leq \text{AUC} < 1.00$ represents "outstanding" discrimination. In order to be useful, the optimal RTW model had to possess sufficient discriminatory power to reject the null hypothesis that its discriminant accuracy was no better than chance alone at a level of $p < .05$.[32]

After displaying the results of the investigation into the optimal RTW model's calibration and discrimination, two additional descriptive measures (Nagelkerke R^2 and Cox and Snell R^2) of goodness-of-fit were presented.[33] Both are effect size measures that capture calibration *and* discrimination aspects of a model and therefore offer insight into a model's overall predictive performance. Unfortunately, in logistic regression, these measures are merely analogs to R^2 in multiple linear regression and they do not have the same variance interpretation (i.e., the proportion of the variation in the dependent variable that can be explained by the combination of independent variables in the model). Nevertheless, they do approximate the interpretation and are useful in providing supplementary information about the goodness-of-fit of a model (Peng, Lee, & Ingersoll, 2002, p. 6).

- Research question 4: How good is the optimal RTW model at classifying a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
    - Hypothesis 4: The ability of the optimal RTW model to classify a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

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[32] This is a minimum standard as the optimal RTW model must have at least "acceptable" discriminant ability to be practically useful.

[33] The Nagelkerke measure is of primary relevance in terms of interpretation as it adjusts the Cox and Snell measure in order to achieve a maximum value of one.

The answer to this research question focused on the accuracy of the optimal RTW model regarding its ability to correctly predict whether injured employees who sustain permanent impairment and receive VR services do or do not RTW as of claim closure. A classification table, which displays the percentage of overall cases correctly identified, was provided to document the validity of the optimal RTW model's predicted probabilities. In addition to the overall classification rate (which indicated whether the optimal RTW model predicted actual observed RTW outcomes better than chance or the base rate alone), other summary statistics that were presented include the model's specificity (ability of a measure to identify a non-case correctly), sensitivity (ability of a measure to identify a case correctly), positive predictive value (proportion of study participants with a positive result who do have the outcome of interest), and negative predictive value (proportion of study participants with a negative result who do not have the outcome of interest) (Polit & Beck, 2008, p. 464-465). These measures are important indicators of the accuracy *and* precision of models designed to predict binary outcomes such as whether injured employees do or do not RTW as of the closure of their workers' compensation claim.

Model validation.

- Research question 5: How good is the optimal RTW model at classifying a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
    - Hypothesis 5: The ability of the optimal RTW model to classify a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Answering this research question required a comparison of the optimal RTW model's predicted probabilities and the validation dataset's observed RTW outcomes. As part of this comparison, the relationship between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes was assessed in terms of its significance and magnitude. The significance of this association was evaluated with a chi-square test of independence and the magnitude of the association was measured using the phi coefficient. Results of the chi-square test of independence were used to determine whether or not the null hypothesis that the optimal RTW model's predicted probabilities and the validation dataset's observed RTW outcomes were independent from one another could be rejected. Meanwhile, the phi coefficient (φ) offered a measure of the effect size for the chi-square test of independence with φ values of .10, .30 and .50 corresponding to small, medium, and large effects, respectively (Cohen, 1988).

After determining the extent of the correlation between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes, an evaluation of the model's internal validity was conducted. This internal validation process involved assessing the classification accuracy of the optimal RTW model when applied to the validation dataset.[34] Identical to research question four, the optimal RTW model's classification accuracy was assessed according to multiple measures, including its overall classification rate, specificity and sensitivity rates (and balanced accuracy), and positive and negative predictive values. In addition to a significant relationship between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes, a higher degree of internal validity would be substantiated by only small differences in performance (i.e., classification accuracy) when applying the model to the development and validation datasets. Further, if the overall

[34] This is consistent with Steyerberg's assertion that "internal validation assesses validity for the setting where the development data originated from" (2010, p. 299).

classification rate(s) of the optimal RTW model supported the hypotheses associated with research questions four *and* five, this would confirm that the optimal RTW model was able to accurately predict the *accessible population's* RTW status as of claim closure better than chance (or the base rate) alone.[35]

Adequacy of Dataset Size

As previously discussed, the ratio of cases (or events) per variable (EPV) is a key consideration when using logistic regression. Results of this statistical technique could have been problematic if there were too few outcome events (e.g., RTW; no RTW) relative to the number of independent variables included in the model (Concato, Feinstein, & Holford, 1993). The major concerns with low EPV values pertain to the stability of the regression coefficients. For example, low EPV values increase the likelihood of having inaccurate and/or imprecise regression coefficients (e.g., extremely large parameter estimates and/or standard errors) and incorrect directions of association. While a common rule of thumb to avoid such errors is that logistic regression models should be used with a minimum of 10 EPV, larger sample sizes have been recommended when using a split-dataset approach to assess a model's internal (e.g., EPV ≥ 40) and external (e.g., EPV ≥ 20 in the validation dataset) validity (Steyerberg et al., 2001). When considering only main effects, a full model would include 49 predictors after dummy coding (i.e., 15 categorical predictor variables with a total of 64 levels). Thus, without taking interaction effects into account, there should ideally have been at least 1,960 claims of injured employees who satisfied the eligibility criteria for both levels of the outcome (i.e., those who did RTW and those who did not RTW as of claim closure) in the development *and* validation

[35] The optimal RTW model's ability to *precisely* predict the accessible population's RTW status as of claim closure would depend on its positive predictive value(s) which is a measure of the precision of a binary classification model.

datasets in order to have fulfilled the recommendation of having an EPV value of 40 or greater.[36] From 2007 through 2011, approximately 56.0% of injured Minnesota employees who received VR services had returned to work as of the closure of their VR plan while about 44.0% had not (Berry & Zaidman, 2013, p. 27). Fortunately, the RTW rates (as of claim closure) of the accessible population were relatively similar as 62.3% of all claims included in the study were made by injured employees who did RTW and 37.7% were made by those who did not RTW. The full dataset of 15,372 claims (including the development dataset of 7,648 claims and the validation dataset of 7,724 claims) of injured employees who sustained permanent impairment and who received VR services consequently easily exceeded the minimum sample size recommendations when using logistic regression analysis (e.g., 37.7% of 7,648 claims is equal to 2,883 claims).[37]

Methodological Limitations

There were four noteworthy limitations of this RTW outcomes study. First, this study was limited by the inherent disadvantages associated with correlational research. The major disadvantage of correlational studies relative to experimental studies is that they are weaker in their ability to identify causal relationships (Polit & Beck, 2008, p. 272). Given the lack of control over potentially confounding variables and the resulting inability to rule out competing explanations of why an injured employee did or did not RTW, there was no attempt to infer cause-and-effect relationships between (or among) study variables. The intent of this

[36] To meet the EPV value of 40 or greater recommendation, a model that included (first-order) interaction effects would require somewhat more than 1,960 eligible injured employee claims for both levels of the outcome if the model included more than 49 predictors (varying depending on the specific number of predictors).

[37] This suggests that problems (e.g., extremely large parameter estimates and standard errors) that often occur when there are too few cases relative to the number of predictor variables should not arise in any main effects only model that is developed in this study. Such problems would be more likely to occur in models that take into account main and first-order interaction effects and that include well in excess of 49 predictors.

retrospective design was strictly to identify antecedent factors that were correlated with, and predictive of, RTW outcomes of the target population. Second, the retrospective nature of this study prevented the collection of data on some predictor variables (e.g., psychosocial variables) which prior research suggests are associated with various RTW outcomes. Also, as indicated by Talley (1988), researchers conducting a secondary data analysis such as this one are constrained by the variables that are accessible in the database under review. The lack of knowledge of potentially important prognostic factors may very well have limited the predictive capacity of the optimal RTW model that was developed and validated in this study. Third, a prerequisite for data access was that all injured employee information regarding the variables of interest be made available as discrete rather than continuous data. This necessarily resulted in some degree of information loss, and possibly a reduction in statistical power, as certain variables (e.g., age) had to be converted to lower levels of measurement prior to this researcher's data receipt. Fourth, the RTW outcome used in this study was a binary measure of an injured employee's RTW status at a single point in time (i.e., as of claim closure). It is possible that this singular method of measuring such a dynamic outcome failed to adequately account for the actual impact of an employee's injury on his or her RTW experience. However, as this study was conducted in a workers' compensation setting, an injured employee's RTW status as of claim closure was of particular relevance.

Chapter 4: Analysis

Introduction

The data analysis procedures for this study were selected in order to achieve this study's purpose of identifying the most parsimonious set of rehabilitation outcome explanatory variables (including medical, individual, and workplace factors) that precisely and accurately predicts the RTW status as of claim closure of injured employees who sustained permanent impairment and who received VR services in Minnesota's workers' compensation system. This chapter is organized according to these procedures, which include descriptive (including univariate and bivariate) and predictive analyses. Descriptive univariate analysis results are reported first and describe the study's accessible population according to the variables of interest. Descriptive bivariate analysis results are then reported to demonstrate the relationships between study variables. Lastly, predictive analysis results are reported to establish the extent of the relationship between the RTW outcome and the set of rehabilitation predictors. Predictive analysis results also include a description of the split dataset validation process and the presentation of the optimal predictive model of RTW status as of claim closure that was developed and validated using data collected from the accessible population of claims of injured Minnesota employees who sustained permanent impairment and received VR services.

Descriptive Univariate Analysis

As all study variables were discrete, the accessible population can best be described through frequency (*n*) and relative frequency (%) distributions. The distributions of the accessible population across each study variable, including five medical factors (nature of injury or illness; part of body affected; severity of permanent impairment; time from date of injury to VR service initiation; pre-existing claim status), five individual factors (age; sex; education; marital status; residence), five workplace factors (job tenure; pre-injury average weekly wage; attorney involvement; pre-injury occupation; pre-injury industry), and one rehabilitation outcome (RTW status as of claim closure), are described as well as presented in tabular format in the following four subsections.

Medical factors.

The medical factor frequency distributions presented in Table 2 reveal that nearly one-half (48.2%) of all work-related incidents of the accessible population of claims of injured employees who sustained permanent impairment and received VR services involved traumatic injuries to muscles, tendons, ligaments, and joints (e.g., sprains, strains, and tears[38]). They also reveal that, irrespective of the nature of injury or illness, the most common body parts affected were the back (24.6%), the trunk and body systems (21.6%), and the lower extremities (19.2%). Regarding injury or illness severity, about seven out of ten (70.5%) claims filed by members of the accessible population with a known impairment rating were assigned a work-related permanent impairment to the whole body of 10% or less. Almost two in ten (18.5%) claims filed by those with a known impairment rating were assigned a whole person permanent impairment of 11% to 15% and just over one in ten (10.9%) were assigned a whole person permanent

[38] "Sprains, strains and tears" was identified as the nature of injury or illness for 42% of the broader population of claims filed by injured employees who received cash benefits in 2011 (Minnesota DLI, 2013).

Table 2

Descriptive Statistics for Medical Factors

Variable	*n*	%
Nature of Injury or Illness		
Traumatic injuries to bones, nerves, spinal cord	1,497	9.7
Traumatic injuries to muscles, tendons, ligaments, joints	7,411	48.2
Wounds, bruises and burns	1,237	8.0
Non-specified pain-related conditions	2,492	16.2
Multiple traumatic injuries and disorders	537	3.5
Other and non-classifiable injuries or illnesses	2,198	14.3
Part of Body Affected		
Head and neck, including throat	576	3.7
Trunk and body systems	3,252	21.2
Upper extremities	2,439	15.9
Lower extremities	2,959	19.2
Back (including spine and spinal cord)	3,775	24.6
Multiple body parts	2,371	15.4
Severity of Permanent Impairment		
1% to 5%	4,383	28.5
6% to 10%	3,778	24.6
11% to 15%	2,142	13.9
16% to 20%	687	4.5
21% or more	578	3.8
Unknown	3,804	24.7
Time from Date of Injury to VR Service Initiation		
3 months or less	5,689	37.0
Between 3 and 6 months	4,734	30.8
Between 6 and 12 months	2,888	18.8
Between 12 and 18 months	1,061	6.9
18 months or more	1,000	6.5
Pre-Existing Claim Status		
One or more prior workers' compensation claims	7,658	49.8
No prior workers' compensation claim	7,714	50.2

impairment greater than 15%. Most claims included in this study were filed by injured employees who had relatively short stints between their date of injury and VR service initiation

(67.8% within 6 months). In addition, approximately one-half (49.8%) of all claims were filed by injured employees with pre-existing workers' compensation claims.

Individual factors.

The individual factor frequency distributions presented in Table 3 indicate that the most common characteristics of the accessible population were being between the ages of 45 and 54, being male, having a high school diploma or its equivalent, being married, and living in a metropolitan area. A review of aggregate data of indemnity claim characteristics suggests that

Table 3

Descriptive Statistics for Individual Factors

Variable	*n*	%
Age		
18 to 24 years	682	4.4
25 to 34 years	2,090	13.6
35 to 44 years	3,887	25.3
45 to 54 years	5,299	34.5
55 to 64 years	3,414	22.2
Sex		
Male	10,509	68.4
Female	4,863	31.6
Education		
Less than high school	1,636	10.6
High school or general equivalency diploma	5,016	32.6
Some post-secondary courses but no degree	3,593	23.4
Post-secondary vocational/technical program	4,077	26.5
Bachelor's degree or higher	1,050	6.8
Marital Status		
Married	8,739	56.9
Not married	6,633	43.1
Residence		
Metropolitan	10,304	67.0
Non-metropolitan	5,068	33.0

this study's dataset was similar to the broader population of claims of injured Minnesota employees who receive cash (indemnity) benefits in terms of sex as, in 2011, 62% of such claimants were male (Minnesota DLI, 2013). Additional aggregated data made available by the Minnesota DLI (n.d.) suggests that the claims comprising this study's dataset were filed by injured employees that were likely somewhat older than the average claimant receiving cash benefits (i.e., average age of 42.7 years in 2008). Not surprisingly, the large majority (82.5%) of the claims of injured employees included in this study involved workers whose highest level of educational attainment was a high school diploma or its equivalent or some college education without a four-year degree. Also, just over one-half (56.9%) of the accessible population was married while about two-thirds (67.0%) resided in a metropolitan area at the time of their work-related incident.

Workplace factors.

The workplace factor frequency distributions presented in Table 4 show that the accessible population was relatively evenly dispersed across the various levels of job tenure and pre-injury average weekly wage. Though difficult to determine with certainty given the categorical nature of available data, based on the mean job tenure (6.7 years) and pre-injury average weekly wage ($689) of injured Minnesota employees who received cash benefits in 2008, the injured employee claims included in this study appear to be comparable to this broader population (Minnesota DLI, n.d.). This study's accessible population was also similar to all injured Minnesota employees with indemnity claims with respect to their pre-injury occupation and industry as most were employed in blue-collar work (65.2%) in the construction, manufacturing, and trade, transportation, and utilities industries (60.9%). Finally, just over one-

Table 4

Descriptive Statistics for Workplace Factors

Variable	*n*	%
Job Tenure		
Less than 1 year	3,855	25.1
1 to 5 years	4,803	31.2
More than 5 years	6,714	43.7
Pre-Injury Average Weekly Wage		
$500 or less	3,248	21.1
$501 to $750	4,379	28.5
$751 to $1,000	3,525	22.9
$1,001 or more	4,220	27.5
Attorney Involvement		
Attorney involved	8,376	54.5
No attorney involved	6,996	45.5
Pre-Injury Occupation		
Blue-collar work	10,018	65.2
White-collar work	2,073	13.5
Pink-collar work	3,281	21.3
Pre-Injury Industry		
Natural resources and mining	240	1.6
Construction	2,530	16.5
Manufacturing	3,109	20.2
Trade, transportation, and utilities	3,725	24.2
Information	236	1.5
Financial activities	313	2.0
Professional and business services	1,077	7.0
Education and health services	2,629	17.1
Leisure and hospitality	558	3.6
Other services	380	2.5
Public administration	575	3.7

half (54.5%) of all claims of injured employees used in this study were filed by workers who were represented by an attorney.

Rehabilitation outcome.

As can be seen with a review of Table 5, the RTW rate of the injured employees who sustained permanent impairment and received VR services and whose claims comprised this study's dataset was 62.3%. This can be compared with the average RTW rate of VR participants in Minnesota from 2007 to 2011 which was 56.0% (Berry & Zaidman, 2013). Thus, the RTW rate of this study's accessible population was slightly higher, but generally similar, to that of the broader population of VR participants in Minnesota in recent years.

Table 5

Descriptive Statistics for the Rehabilitation Outcome

Variable	*n*	%
RTW Status as of Claim Closure		
RTW	9,574	62.3
No RTW	5,798	37.7

Descriptive Bivariate Analysis

To further describe this study's accessible population, an investigation of the bivariate relationships between all study variables was performed.[39] Of particular interest was the relationship between each predictor variable and the outcome. The results of this bivariate analysis are provided in tabular format in this section. Specifically, a correlation matrix displaying the magnitude of the associations among study variables is initially presented and is followed by contingency tables that portray the relationship between each predictor and the outcome by revealing the RTW rates of injured employees at each level of this study's independent variables.

[39] As previously noted, this study's accessible population was technically all injured employee *claims* (rather than injured employees themselves as some employees file multiple claims) that were in the Minnesota workers' compensation claims database and that satisfied all eligibility criteria. However, for simplicity, bivariate analysis results are presented in reference to injured employees rather than injured employee claims.

The correlation matrix presented in Table 6 demonstrates that, among the accessible population, attorney involvement (φ_c = .46) and severity of permanent impairment (φ_c = .43) had *relatively strong* associations with RTW status as of claim closure. There were *weak* associations between RTW status as of claim closure and job tenure (φ_c = .16), pre-injury average weekly wage (φ_c = .14), part of body affected (φ_c = .12), and education (φ_c = .12). Finally, there were *negligible* associations between RTW status as of claim closure and pre-injury industry (φ_c = .09), nature of injury or illness (φ_c = .06), marital status (φ_c = .05), pre-injury occupation (φ_c = .04), time from date of injury to VR service initiation (φ_c = .04), sex (φ_c = .03), pre-existing claim status (φ_c = .03), age (φ_c = .02), and residence (φ_c = .01). Thus, of the independent variables with more than negligible associations with the outcome, three were workplace factors (attorney involvement; job tenure; pre-injury average weekly wage), two were medical factors (severity of permanent impairment; part of body affected) and one was an individual factor (education).

Even though the magnitude of 13 of the 15 bivariate relationships between each predictor and RTW status as of claim closure can be described as weak or negligible, a closer inspection of the variation in RTW rates at different levels of several predictors nevertheless exposed several important findings. These findings are identified in the following three subsections.

Medical factors.

In Table 7, the RTW rates of injured employees in Minnesota who sustained permanent impairment and who received VR services and whose claims were included in this study are presented at each level of the medical factor variables. The most significant discrepancy in RTW rates among medical factors was according to severity of permanent impairment. While more than three out of four (76.7%) injured employees with a permanent impairment rating of 1% to

Table 6

Correlation Matrix of Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Nature of Injury or Illness	-	.27	.07	.09	.11	.05	.07	.03	.03	.03	.08	.04	.08	.04	.07	.06
2 Part of Body Affected		-	.21	.07	.08	.08	.10	.04	.04	.02	.07	.05	.21	.06	.08	.12
3 Severity of Permanent Impairment			-	.03	.04	.07	.08	.05	.06	.03	.12	.07	.49	.03	.05	.43
4 Time from DOI to VR Service Initiation				-	.05	.05	.08	.02	.02	.02	.09	.03	.08	.03	.05	.04
5 Pre-Existing Claim Status					-	.23	.09	.10	.04	.01	.15	.14	.02	.09	.09	.03
6 Age						-	.06	.06	.20	.03	.24	.10	.11	.05	.07	.02
7 Sex							-	.08	.08	.00	.04	.33	.07	.50	.48	.03
8 Education								-	.04	.07	.07	.13	.14	.22	.14	.12
9 Marital Status									-	.07	.15	.13	.06	.05	.08	.05
10 Residence										-	.03	.09	.02	.07	.12	.01
11 Job Tenure											-	.24	.21	.06	.16	.16
12 Pre-Injury Average Weekly Wage												-	.15	.21	.25	.14
13 Attorney Involvement													-	.05	.10	.46
14 Pre-Injury Occupation														-	.50	.04
15 Pre-Injury Industry															-	.09
16 RTW Status as of Claim Closure																-

Note. DOI = date of injury.

Table 7

RTW Rates of Injured Employees by Medical Factors

Variable	%
Nature of Injury or Illness	
Traumatic injuries to bones, nerves, spinal cord	69.8
Traumatic injuries to muscles, tendons, ligaments, joints	62.7
Wounds, bruises and burns	62.3
Non-specified pain-related conditions	59.9
Multiple traumatic injuries and disorders	61.5
Other and non-classifiable injuries or illnesses	58.6
Part of Body Affected	
Head and neck, including throat	53.1
Trunk and body systems	67.5
Upper extremities	61.3
Lower extremities	70.3
Back (including spine and spinal cord)	55.5
Multiple body parts	59.1
Severity of Permanent Impairment	
1% to 5%	76.7
6% to 10%	75.2
11% to 15%	73.8
16% to 20%	65.2
21% or more	58.1
Unknown	26.6
Time from Date of Injury to VR Service Initiation	
3 months or less	64.0
Between 3 and 6 months	61.5
Between 6 and 12 months	62.6
Between 12 and 18 months	59.2
18 months or more	58.0
Pre-Existing Claim Status	
One or more prior workers' compensation claims	60.9
No prior workers' compensation claim	63.6

5% returned to work as of claim closure, fewer than six out of ten (58.1%) injured employees with a permanent impairment rating of 21% or more accomplished this goal. The RTW rates of injured employees with permanent impairment ratings between these two extremes also declined as the level of permanent impairment increased. This strongly suggests that the less severe an injured employee's permanent impairment, the more likely he or she is to successfully RTW as of claim closure. There was also conspicuous variation in the RTW rates according to the part of body affected by an injured employee's work-related incident. While those who sustained injuries to their lower extremities (70.3%) or their trunk and body systems (67.5%) returned to work as of claim closure just over two-thirds of the time, those who sustained injuries to their back (55.5%) or head and/or neck (53.1%) remained out of work as of claim closure nearly one-half of the time. Injured employees who sustained injuries to their upper extremities (61.3%) or to multiple body parts (59.1%) returned to work as of claim closure in approximately six out of ten cases.

Less variation existed between RTW status as of claim closure and the following independent variables: nature of injury or illness; time from date of injury to VR service initiation; pre-existing claim status. Regarding nature of injury or illness, RTW rates were highest (69.8%) among those who had sustained a traumatic injury to their bones, nerves, or spinal cord (e.g., fracture) and lowest (58.6%) among those who had sustained other and non-classifiable injuries or illnesses (e.g., intracranial injury). Regarding time from the date of injury to VR service initiation, RTW rates were highest (64.0%) when this time was less than three months and lowest when this time was more than 18 months (58.0%). Though the relationship was not strong, these results suggest that the quicker VR services were initiated relative to an injured employee's date of injury (or illness), the more likely he or she was to RTW as of claim closure. Regarding pre-existing claim status, injured employees with no prior workers' compensation claim were only slightly more likely to RTW as of claim closure than those with at least one prior workers' compensation claim (63.6% to 60.9%). Consequently, an injured employee's pre-existing claim status appears to be a poor predictor of whether he or she would RTW as of claim closure after sustaining permanent impairment and receiving VR services.

Individual factors.

The RTW rates of this study's accessible population are presented for each level of the individual factor variables in Table 8. As previously noted, education was the only individual factor that was more than negligibly associated with this study's work disability outcome. The RTW rates of injured employees whose highest level of education consisted of a high school diploma or its equivalent (63.2%), some post-secondary coursework but no degree (61.4%), or completion of a post-secondary vocational/technical program (65.3%) were similar to the overall RTW rate of injured employees whose claims comprised the accessible population (62.3%). However, while nearly three-fourths (72.7%) of injured employees who had a bachelor's degree or more returned to work as of claim closure, this was the case for fewer than one-half (47.4%) of injured employees with a less than high school education. Injured employees who were married (64.4%) were more likely to RTW as of claim closure relative to those who were not married (59.6%). Similarly, injured male employees (63.3%) had resumed gainful employment as of claim closure at a slightly higher rate than injured female employees (60.1%). The age of injured employees appeared to be an inadequate indicator of RTW status as of claim closure as the RTW rates of those ages 25 to 34 years (62.0%), 35 to 44 years (62.1%), 45 to 54 years (62.3%), and 55 to 64 years (61.8%) were virtually identical. The only disparate group was injured employees aged 18 to 24 years. Members of this age group returned to work as of claim closure in approximately two out of three cases (66.3%). Lastly, injured employees residing in

Table 8

RTW Rates of Injured Employees by Individual Factors

Variable	%
Age	
18 to 24 years	66.3
25 to 34 years	62.0
35 to 44 years	62.1
45 to 54 years	62.3
55 to 64 years	61.8
Sex	
Male	63.3
Female	60.1
Education	
Less than high school	47.4
High school or general equivalency diploma	63.2
Some post-secondary courses but no degree	61.4
Post-secondary vocational/technical program	65.3
Bachelor's degree or higher	72.7
Marital Status	
Married	64.4
Not married	59.6
Residence	
Metropolitan	61.9
Non-metropolitan	63.0

non-metropolitan areas (63.0%) were only marginally more likely to RTW as of claim closure than those residing in metropolitan areas (61.9%).

Workplace factors.

The RTW rates of injured Minnesota employees whose claims were included in this study are presented for each level of the workplace factor variables in Table 9. It is readily apparent that attorney involvement resulted in the greatest divergence in this study's rehabilitation outcome. While nearly seven out of eight (86.8%) injured employees without legal

Table 9

RTW Rates of Injured Employees by Workplace Factors

Variable	%
Job Tenure	
Less than 1 year	51.3
1 to 5 years	60.1
More than 5 years	70.1
Pre-Injury Average Weekly Wage	
$500 or less	52.5
$501 to $750	58.3
$751 to $1,000	66.4
$1,001 or more	70.4
Attorney Involvement	
Attorney involved	41.8
No attorney involved	86.8
Pre-Injury Occupation	
Blue-collar work	61.8
White-collar work	67.0
Pink-collar work	60.7
Pre-Injury Industry	
Natural resources and mining	60.0
Construction	61.5
Manufacturing	59.8
Trade, transportation, and utilities	64.1
Information	67.4
Financial activities	57.2
Professional and business services	54.2
Education and health services	65.7
Leisure and hospitality	55.0
Other services	61.1
Public administration	76.2

representation returned to work as of claim closure, just over four out of ten (41.8%) injured employees with legal representation attained this goal. Bivariate analysis results also suggest that job tenure and pre-injury average weekly wage may have contributed to some variation in the RTW status as of claim closure in this study's accessible population. Specifically, higher RTW rates were achieved by injured employees who had longer job tenure with their pre-injury employer and who had a higher pre-injury average weekly wage. With respect to job tenure, seven out of ten (70.1%) injured employees who had worked with their pre-injury employer for more than five years returned to work as of claim closure. For those who had worked with their pre-injury employer for one to five years, six out of ten (60.1%) obtained a successful RTW outcome. The RTW rate declined to just over five out of ten (51.3%) for those who had worked with their pre-injury employer for less than one year. With respect to pre-injury average weekly wage, seven out of ten (70.4%) injured employees who earned more than $1,000 in a typical week before their work-related incident returned to work as of claim closure. The RTW rate was somewhat lower for injured employees who had a pre-injury average weekly wage between $751 and $1,000 as two-thirds (66.4%) of the members of this group were able to successfully RTW. The RTW rates were considerably lower for those who typically earned between $501 and $750 (58.3%) and less than $500 (52.5%) per week.

The associations between RTW status as of claim closure and pre-injury occupation and industry were less significant than the relationships between this rehabilitation outcome and the other three workplace factor variables. Nevertheless, knowledge of the occupation and industry in which an injured employee worked prior to his or her work-related incident may be of some assistance when predicting whether he or she will RTW as of claim closure. While more than three-fourths (76.2%) of injured employees who previously worked in public administration did RTW as of claim closure, those who had worked in several other industries achieved this outcome at significantly lower rates. For example, injured employees who previously worked in manufacturing (59.8%), financial activities (57.2%), leisure and hospitality (55.0%), and professional and business services (54.2%) returned to work as of claim closure less than 60% of the time. In addition, while injured employees who were previously performing white-collar work (67.0%) attained a successful RTW outcome approximately two-thirds of the time, those who were performing blue-collar work (61.8%) or pink-collar work (60.7%) at the time of their work-related incident had lower RTW rates.

Predictive Analysis

A predictive analysis was performed to determine whether the rehabilitation outcome predictors included in this study were related to the RTW status as of claim closure of injured Minnesota employees who sustained permanent impairment and received VR services. After verification of this relationship, an optimal predictive model of RTW status as of claim closure was developed and [internally] validated on a split dataset of this study's accessible population. This predictive analysis thus included model development and validation processes and was completed by testing hypotheses associated with five research questions. The following is a restatement of these research questions and associated hypotheses accompanied by a presentation of the answers to each of these questions:

Model development.

- <u>Research question 1</u>: Does knowledge of the full set of RTW outcome predictor variables make a difference in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - <u>Hypothesis 1</u>: Knowledge of the full set of RTW outcome predictor variables does make a difference (i.e., is helpful) in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

This initial research question was an important first step in the determination of whether the available information (including medical, individual, and workplace factors) about injured employees in Minnesota who had sustained permanent impairment and had received VR services was helpful in predicting their RTW status as of claim closure. If the findings would have suggested that the null hypothesis of there being no association between this study's predictors and its outcome could not have been rejected, a useful predictive model could not have been developed without acquiring additional information about the accessible population. To answer this research question, a constant-only model was compared with models that had the constant plus *all* predictors (i.e., full models with and without consideration of interaction effects).[40] When considering all main and first-order interaction effects, the test of the full model with the constant-only model was statistically significant, χ^2 (1,126, N = 7,648[41]) = 3,773.28, $p < .001$. This result offered strong evidence that the null hypothesis of no association between the predictors and the outcome could be rejected. Similarly, the test between the full main effects only model with the constant-only model was statistically significant, χ^2 (49, N = 7,648) = 2,447.34, $p < .001$. Thus, the existence of a relationship between this study's predictors and the development dataset's RTW status as of claim closure was clearly evident even without taking first-order interaction effects into account.

- Research question 2: Can a more parsimonious RTW model be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure

[40] For this study, the constant-only model was compared with a full main effects and first-order interaction effects model and with a full main effects only model (both of these models include the constant).

[41] When conducting this regression analysis, an SPSS warning indicated that the degrees of freedom had been reduced for one or more variables. Based on regression analyses results obtained when applying the full main and first-order interaction effects model to the validation dataset, it appeared that the degrees of freedom were reduced by one (i.e., from 1,127 to 1,126).

in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?

- Hypothesis 2: A reduced RTW model can be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

Because of the complexity of the full main and first-order interaction effects model (which included 1,126 degrees of freedom), this model was simplified so as to only include the first-order interactions between predictors with a bivariate relationship that was more than *negligible* (i.e., $\varphi_c \geq .10$). This served to condense the main and first-order interaction effects model by nearly 70% (i.e., reducing the degrees of freedom from 1,126 to 356) while simultaneously preserving the robust relationship between the predictors and the RTW outcome. This was evidenced by the statistically significant difference between the reduced main and first-order interaction effects model and the constant-only model, χ^2 (356, N = 7,648) = 2,830.24, $p <$ .001. After this simplification procedure, the already reduced main and first-order interaction effects *and* the full main effects only models were (further[42]) reduced using stepwise logistic regression with backward elimination. Preliminary variable selection was based on eliminating predictors that did not meet the Akaike Information Criterion (AIC). Accordingly, all predictor variables included in the reduced main and first-order interaction effects and full main effects only models whose relationship with the RTW outcome was not statistically significant at a level of $p < .157$ were eliminated. Application of this model building method to the reduced main and first-order interaction effects model resulted in the elimination of another 213 degrees of

[42] The term "further" applies to the main and first-order interaction effects model as it was already reduced by only considering first-order interactions between predictors with more than *negligible* bivariate relationships.

freedom (356 to 143). Even with this change in model specification, this reduced main and first-order interaction effects model was statistically significantly different from the constant-only model, χ^2 (142, N = 7,648) = 2,644.07, $p < .001$ (Appendix B). Meanwhile, when employing this same backward elimination process to the full main effects only model, 16 degrees of freedom were removed. This reduced main effects only model was also statistically significantly different from the constant-only model, χ^2 (33, N = 7,648) = 2,431.21, $p < .001$ (Appendix C).

Though Hosmer et al. (2013) do recommend a less stringent criterion (e.g., the AIC) than $p < .05$ for variable selection when employing stepwise logistic regression, the use of a large dataset (e.g., this study's accessible population) increases the risk that relationships (and model differences) that are of no practical importance will nevertheless be statistically significant. In addition, a review of Appendices B and C suggests that both reduced models contain several predictor variables that have relatively little influence on the accessible population's RTW status as of claim closure. For example, the odds ratios of several predictor variables retained in both reduced models were close to 1.00 (i.e., between 0.90 and 1.10). As an odds ratio is interpretable as an effect size, this indicates that some retained predictors using the AIC likely had a small effect on this study's RTW outcome. Consequently, more rigorous criteria were applied to determine whether a more parsimonious model could be developed. When applying the standard criterion of $p < .05$ for variable inclusion, 61 additional degrees of freedom were eliminated from the main and first-order interaction effects model. Nevertheless, the model was statistically significantly different from the constant-only model, χ^2 (81, N = 7,648) = 2,553.24, $p < .001$ (Appendix D). The main effects only model was only slightly condensed (i.e., by one degree of freedom) and its variation from the constant-only model was also statistically significant, χ^2 (32, N = 7,648) = 2,428.17, $p < .001$ (Appendix E). Finally, the variable inclusion criterion of p <

.001 was applied and led to the development of further reduced models. Despite the elimination of another 32 degrees of freedom, the main and first-order interaction effects model's difference with the constant-only model was still statistically significant, χ^2 (49, N = 7,648) = 2,463.02, $p <$ .001 (Table 10). Similarly, the main effects model, which was reduced to 25 degrees of freedom, continued to be statistically significantly different from the constant-only model, χ^2 (25, N = 7,648) = 2,394.03, $p < .001$ (Table 11).

These results (in combination with model performance results presented later) confirmed that, regardless of whether or not first-order interaction effects are considered, a reduced RTW model can be developed that is not reliably different from the full RTW model(s) in its ability to predict this study's outcome. However, the higher chi-square statistic that was obtained when taking interaction effects into account suggested that the performance of the main and first-order interaction effects model would be superior to that of the reduced main effects only model regarding their ability to predict this study's outcome. Use of a model that included [first-order] interaction effects would also be consistent with RTW research which describes [work] disability as a complex interaction of medical and non-medical factors. Thus, apart from applying extremely stringent p-values (i.e., more stringent than $p < .001$) in an effort to remove any remaining doubt about the relationship between the retained predictors and the outcome, it was apparent that the reduced main and first-order interaction effects model presented in Table 10 was most suitable for designation as this study's optimal RTW model.[43] The logistic regression prediction equation for this optimal RTW model, which includes four main effects (including

[43] This decision was based on model specification and performance. In terms of specification, the full main and first-order interaction effects model was highly complex (e.g., 1,127 degrees of freedom) and not practically useful. In terms of performance, results of the omnibus tests of model coefficients revealed that performance was somewhat better when first-order interaction effects were included. Therefore, a reduced main and first-order interaction effects model was appropriate for selection as this study's optimal RTW model.

Table 10

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .001)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-2.95(0.18)	281.45	.00	0.05		
Attorney Involvement						
Attorney involved	2.01(0.14)	220.43	.00	7.49	5.74	9.77
No attorney involved (base)	0.00					
Severity of Permanent Impairment		129.98	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.07(0.12)	0.35	.56	0.93	0.73	1.19
11% to 15%	-0.48(0.17)	7.57	.01	0.62	0.44	0.87
16% to 20%	0.02(0.28)	0.00	.96	1.02	0.59	1.74
21% or more	0.47(0.26)	3.13	.08	1.60	0.95	2.68
Unknown	2.37(0.23)	104.96	.00	10.70	6.80	16.85
Pre-Injury AWW X Pre-Injury Industry		79.35	.00			
$500 or less X Natural res. and mining	0.27(0.43)	0.39	.53	1.31	0.57	3.02
$500 or less X Construction	0.99(0.32)	9.52	.00	2.69	1.43	5.04
$500 or less X Manufacturing	0.55(0.17)	11.18	.00	1.74	1.26	2.41
$500 or less X Trade, trans., and utilities	0.47(0.14)	11.99	.00	1.59	1.22	2.08
$500 or less X Information	0.32(0.59)	0.29	.59	1.37	0.43	4.40
$500 or less X Financial activities	0.62(0.43)	2.08	.15	1.86	0.80	4.34
$500 or less X Prof. and business services	0.62(0.17)	13.21	.00	1.86	1.33	2.60
$500 or less X Education and health serv.	0.32(0.13)	6.09	.01	1.38	1.07	1.78
$500 or less X Leisure and hospitality	0.60(0.19)	10.35	.00	1.81	1.26	2.61
$500 or less X Other services	1.00(0.31)	10.36	.00	2.72	1.48	5.01

Table 10 (continued)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .001)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
$500 or less X Natural res. and mining	-0.16(0.39)	0.16	.69	0.85	0.40	1.83
$501 to $750 X Construction	0.58(0.18)	10.28	.00	1.79	1.25	2.55
$501 to $750 X Manufacturing	0.34(0.11)	9.75	.00	1.41	1.14	1.75
$501 to $750 X Trade, trans., and utilities	0.32(0.12)	7.04	.01	1.38	1.09	1.75
$501 to $750 X Information	-0.07(0.44)	0.02	.88	0.94	0.39	2.23
$501 to $750 X Financial activities	-0.03(0.30)	0.01	.92	0.97	0.54	1.75
$501 to $750 X Prof. and business serv.	0.36(0.20)	3.30	.07	1.44	0.97	2.12
$501 to $750 X Educ. and health serv.	-0.09(0.13)	0.50	.48	0.91	0.70	1.18
$501 to $750 X Leisure and hospitality	0.18(0.29)	0.40	.53	1.20	0.69	2.09
$501 to $750 X Other services	0.32(0.32)	1.00	.32	1.37	0.74	2.54
$751 to $1,000 X Natural res. and mining	0.22(0.54)	0.17	.68	1.25	0.43	3.62
$751 to $1,000 X Construction	-0.00(0.15)	0.00	.99	1.00	0.74	1.34
$751 to $1,000 X Manufacturing	-0.10(0.13)	0.55	.46	0.91	0.70	1.17
$751 to $1,000 X Trade, trans., and util.	0.15(0.13)	1.34	.25	1.16	0.90	1.50
$751 to $1,000 X Information	0.68(0.61)	1.26	.26	1.98	0.60	6.53
$751 to $1,000 X Financial activities	0.08(0.40)	0.04	.84	1.08	0.50	2.34
$751 to $1,000 X Prof. and business serv.	-0.19(0.25)	0.62	.43	0.83	0.51	1.33
$751 to $1,000 X Educ. and health serv.	-0.29(0.19)	2.21	.14	0.75	0.51	1.10
$751 to $1,000 X Leisure and hospitality	0.30(0.52)	0.33	.56	1.35	0.49	3.74
$751 to $1,000 X Other services	-0.43(0.55)	0.62	.43	0.65	0.22	1.90
Age		68.62	.00			
18 to 24 years (base)	0.00					
25 to 34 years	0.24(0.15)	2.53	.11	1.27	0.95	1.70
35 to 44 years	0.35(0.14)	6.06	.01	1.42	1.07	1.88

Table 10 (continued)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .001)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
45 to 54 years	0.56(0.14)	15.88	.00	1.76	1.33	2.32
55 to 64 years	0.90(0.15)	36.70	.00	2.46	1.84	3.29
Job Tenure		61.64	.00			
Less than 1 year	1.01(0.13)	59.90	.00	2.74	2.12	3.54
1 to 5 years	0.27(0.13)	4.24	.04	1.31	1.01	1.69
More than 5 years (base)	0.00					
Attorney Involvement X Severity of PI		35.69	.00			
Attorney involved X 6% to 10%	0.02(0.16)	0.01	.91	1.02	0.74	1.40
Attorney involved X 11% to 15%	0.55(0.21)	6.96	.01	1.74	1.15	2.62
Attorney involved X 16% to 20%	0.48(0.32)	2.19	.14	1.61	0.86	3.03
Attorney involved X 21% or more	-0.02(0.31)	0.01	.94	0.98	0.53	1.81
Attorney involved X Unknown	-1.09(0.25)	19.22	.00	0.34	0.21	0.55
Attorney Involvement X Job Tenure		31.13	.00			
Attorney involved X Less than 1 year	-0.84(0.15)	30.87	.00	0.43	0.32	0.58
Attorney involved X 1 to 5 years	-0.28(0.15)	3.48	.06	0.75	0.56	1.02

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval; PI = permanent impairment; AWW = average weekly wage; Educ. = education; Prof. = professional; res. = resources; trans. = transportation; serv. = services; util. = utilities.

Table 11

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .001)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-2.85(0.22)	168.01	.00	0.06		
Attorney Involvement						
Attorney involved	1.71(0.07)	681.52	.00	5.55	4.88	6.31
No attorney involved (base)	0.00					
Severity of Permanent Impairment		408.73	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.07(0.08)	0.77	.38	0.93	0.80	1.09
11% to 15%	-0.09(0.09)	0.89	.35	0.92	0.76	1.10
16% to 20%	0.36(0.14)	7.00	.01	1.44	1.10	1.88
21% or more	0.44(0.14)	9.70	.00	1.56	1.18	2.05
Unknown	1.35(0.08)	274.39	.00	3.85	3.28	4.51
Age		73.24	.00			
18 to 24 years (base)	0.00					
25 to 34 years	0.22(0.15)	2.26	.13	1.26	0.93	1.69
35 to 44 years	0.34(0.15)	5.55	.02	1.41	1.06	1.87
45 to 54 years	0.57(0.14)	15.80	.00	1.77	1.34	2.34
55 to 64 years	0.91(0.15)	36.83	.00	2.48	1.85	3.33
Pre-Injury Average Weekly Wage		63.23	.00			
$500 or less	0.66(0.09)	50.18	.00	1.94	1.61	2.33
$501 to $750	0.35(0.08)	17.92	.00	1.42	1.21	1.66
$751 to $1,000	0.04(0.08)	0.19	.67	1.04	0.88	1.22

Table 11 (continued)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .001)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
$1,001 or more (base)	0.00					
Pre-Injury Industry		38.74	.00			
Natural resources and mining	-0.16(0.28)	0.32	.58	0.86	0.50	1.48
Construction	0.33(0.17)	3.56	.06	1.39	0.99	1.95
Manufacturing	0.03(0.17)	0.03	.86	1.03	0.74	1.44
Trade, transportation, and utilities	0.03(0.17)	0.03	.87	1.03	0.74	1.43
Information	-0.23(0.30)	0.58	.45	0.80	0.44	1.43
Financial activities	0.03(0.25)	0.02	.90	1.03	0.63	1.70
Professional and business services	0.04(0.19)	0.05	.83	1.04	0.72	1.52
Education and health services	-0.31(0.18)	3.03	.08	0.74	0.52	1.04
Leisure and hospitality	0.03(0.22)	0.02	.89	1.03	0.67	1.57
Other services	0.23(0.24)	0.89	.34	1.25	0.78	2.01
Public administration (base)	0.00					
Job Tenure		28.35	.00			
Less than 1 year	0.40(0.08)	25.77	.00	1.49	1.28	1.73
1 to 5 years	0.09(0.07)	1.43	.23	1.09	0.95	1.25
More than 5 years (base)	0.00					

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval.

one medical factor, one individual factor, and two workplace factors) and three first-order interaction effects (including an interaction between a workplace factor and a medical factor and two interactions between workplace factors) is as follows:

log(p/1-p) = -2.951 + 2.014(Attorney involved) – 0.073(6% to 10% PI) – 0.475(11% to 15% PI) + 0.016(16% to 20% PI) + 0.467(21% PI or more) + 2.371(Unknown PI) + 0.268($500 or less X Natural resources and mining) + 0.989($500 or less X Construction) + 0.554($500 or less X Manufacturing) + 0.466($500 or less X Trade, transportation and utilities) + 0.319($500 or less X Information) + 0.622($500 or less X Financial activities) + 0.622($500 or less X Professional and business services) + 0.322($500 or less X Education and health services) + 0.595($500 or less X Leisure and hospitality) + 1.002($500 or less X Other services) – 0.158($501 to $750 X Natural resources and mining) + 0.580($501 to $750 X Construction) + 0.344($501 to $750 X Manufacturing) + 0.322($501 to $750 X Trade, transportation and utilities) – 0.067($501 to $750 X Information) – 0.030($501 to $750 X Financial activities) + 0.361($501 to $750 X Professional and business services) – 0.094($501 to $750 X Education and health services) + 0.181($501 to $750 X Leisure and hospitality) + 0.315($501 to $750 X Other services) + 0.223($751 to $1,000 X Natural resources and mining) – 0.003($751 to $1,000 X Construction) – 0.097($751 to $1,000 X Manufacturing) + 0.150($751 to $1,000 X Trade, transportation and utilities) + 0.683($751 to $1,000 X Information) + 0.078($751 to $1,000 X Financial activities) – 0.192($751 to $1,000 X Professional and business services) – 0.288($751 to $1,000 X Education and health services) + 0.300($751 to $1,000 X Leisure and hospitality) – 0.429($751 to $1,000 X Other services) + 0.237(25 to 34 years) + 0.351(35 to 44 years) + 0.563(45 to 54 years) + 0.899(55 to 64 years) + 1.008(Less than 1 year) + 0.269(1 to 5 years) + 0.018(Attorney involved X 6% to 10% PI) + 0.552(Attorney involved X 11% to 15% PI) + 0.476(Attorney involved X

16% to 20% PI) – 0.024(Attorney involved X 21% PI or more) – 1.091(Attorney involved X Unknown PI) – 0.837(Attorney involved X Less than 1 year) – 0.283(Attorney involved X 1 to 5 years), where p is the probability of RTW as of claim closure.

- Research question 3: How well does the optimal RTW model (i.e., the most parsimonious model that reliably predicts the outcome) fit observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
    - Hypothesis 3: Predicted RTW outcomes from the optimal RTW model are not significantly different from observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

The goodness-of-fit of the optimal RTW model (i.e., at a *p*-value of .001) was chiefly assessed according to two distinct components of a logistic regression model's accuracy: calibration and discrimination. Calibration, which is a measure of the extent to which a model's predicted outcomes correspond to observed outcomes, was formally evaluated using the Hosmer-Lemeshow (H-L) test. The results of this test were found to be statistically insignificant, χ^2 (8, *N* = 7,648) = 10.617, *p* = .224, suggesting a high level of agreement between the model's RTW predictions and the development dataset's actual RTW outcomes. Though this was a desirable result, further evaluation of the optimal RTW model's calibration was performed at the behest of Hosmer et al. (2013) who advise that "one must use all the information available to make an informed decision about the fit of [a] model" (p. 169). Included among this information were the predicted and observed frequencies within each decile of risk of failure to RTW as of claim closure for both outcome groups (i.e., claims of injured employees who did and who did not

RTW as of claim closure). These frequencies (and relative frequencies) are presented for both of this study's outcome groups in Table 12. If a logistic regression model fits a dataset well, then most cases (e.g., injured employees who filed workers' compensation claims) in which an undesirable outcome is obtained (e.g., failure to RTW as of claim closure) are in the higher deciles of risk (Tabachnick & Fidell, 2007, p. 459). Likewise, most who obtain a positive outcome (e.g., successful RTW as of claim closure) are in the lower deciles of risk. A review of Table 12 plainly reveals this to be the case with regard to the claims of injured employees comprising this development dataset. That is, the large majority of claims of injured employees who did RTW as of claim closure were in the lower risk deciles for failure to RTW while those who did not RTW as of claim closure were predominantly in the higher risk deciles of this outcome. In addition, in absolute and relative terms, the predicted and observed outcomes were very similar across each risk decile for claims of injured employees who did and who did not RTW.

Another method of assessing model calibration is to perform a linear regression of predicted and observed decile means (Kramer & Zimmerman, 2007). A signal that the model calibrates well is that the linear regression line has an equation ($Y = a + bX$) with a slope (b) that approaches one and an intercept term (a) that is not statistically significantly different from zero. When treating the predicted decile means as the independent variable and the observed decile means as the dependent variable, the regression line had a slope of 0.999 and an intercept term of0.441. This intercept term was found to be not statistically significantly different from zero, $t(19) = 0.076$, $p = .940$. A graphical representation of the development dataset's predicted and observed decile means is provided in Figure 4. This scatter plot demonstrates that there is little deviation from the 45-degree line (i.e., regression line slope = 1) that represents a perfect fit.

Table 12

Predicted and Observed Frequencies (Number) and Relative Frequencies (Percent) within each Decile of Risk of Failure to RTW as of Claim Closure for Claims of Injured Employees who did and who did not RTW in the Development Dataset

	Claims of Injured Employees who did RTW				Claims of Injured Employees who did not RTW				
Deciles of Risk of Failure to RTW as of Claim Closure	Number		Percent		Number		Percent		Total
	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	
1-10%	725	731	93.9	94.7	47	41	6.1	5.3	772
11-20%	705	703	91.7	91.4	64	66	8.3	8.6	769
21-30%	683	688	89.0	89.7	84	79	11.0	10.3	767
31-40%	643	634	84.1	82.9	122	131	15.9	17.1	765
41-50%	530	530	69.4	69.4	234	234	30.6	30.6	764
51-60%	443	427	57.7	55.6	325	341	42.3	44.4	768
61-70%	381	395	49.5	51.4	388	374	50.5	48.6	769
71-80%	293	285	38.5	37.5	468	476	61.5	62.5	761
81-90%	212	237	27.8	31.1	551	526	72.2	68.9	763
91-100%	147	132	19.6	17.6	603	618	80.4	82.4	750
Total	4,762	4,762	62.3	62.3	2,886	2,886	37.7	37.7	7,648

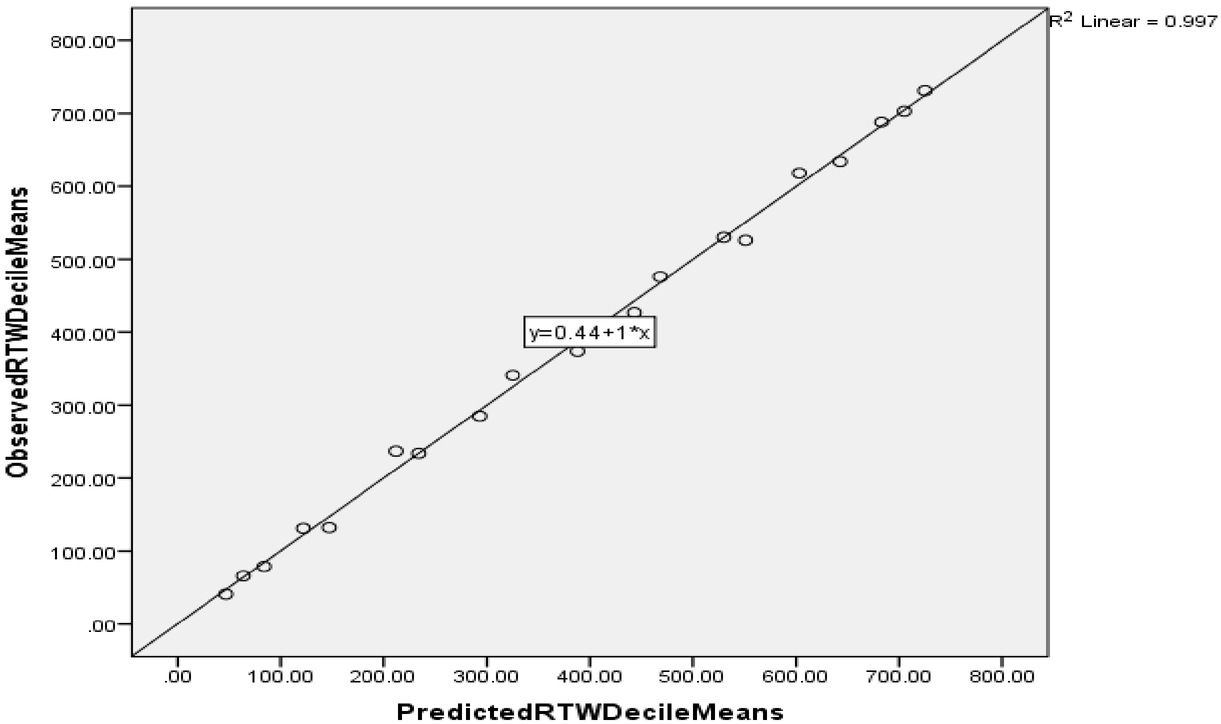

Figure 4. Scatter Plot of Predicted and Observed RTW Decile Means in the Development Dataset.

Further investigation of model calibration thus established that the optimal RTW model's predicted probabilities were indeed reflective of the development data set's actual (or observed) outcomes. At a minimum, this finding offered compelling evidence that the model's calibration is adequate for it to be a useful tool for predicting the RTW status as of claim closure of this study's development dataset (and potentially its entire accessible population).

A second component of a model's goodness-of-fit is discrimination, which refers to how well a model can discern between those who do and who do not have (or who will and who will not obtain) the outcome of interest. The discriminant ability of the development dataset's optimal RTW model was assessed by constructing a receiver operating characteristic (ROC) curve, which is presented in Figure 5. Models with strong power have ROC curves that approach the upper left hand corner. Conversely, models with weak discriminatory power have ROC curves

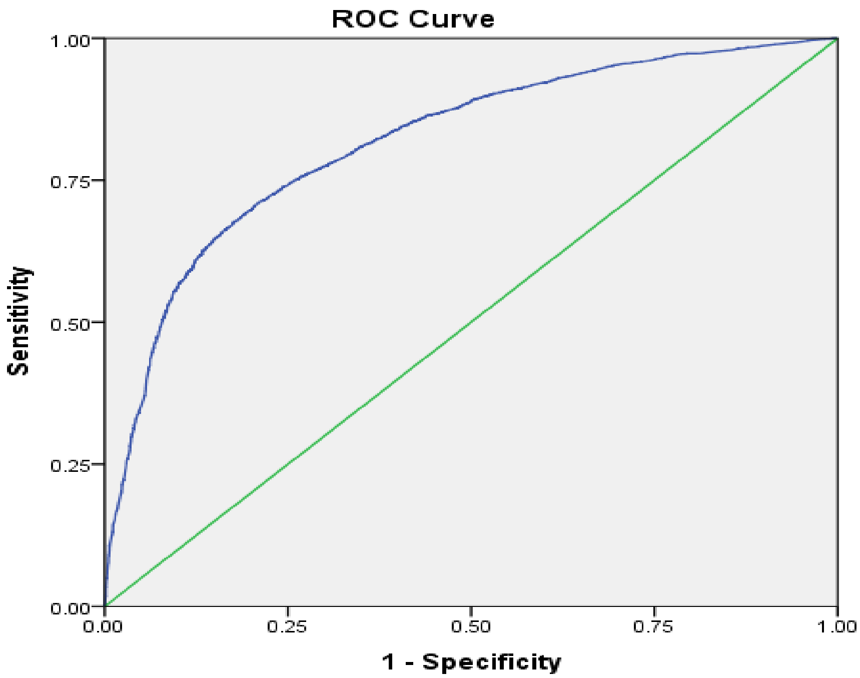

Figure 5. ROC Curve of the Optimal RTW Model when Applied to the Development Dataset.

that remain near the diagonal. Therefore, the area under the curve, or AUC, is of particular relevance. The optimal RTW model had an AUC, which is represented by a *c*-statistic, of .818, 95% CI [.808, .828].[44] This indicated that there is an 81.8% chance that a randomly selected negative case (i.e., claim of an injured employee who did not RTW as of claim closure) would have a higher predicted probability of failure to RTW as of claim closure than a randomly selected positive case (i.e., claim of an injured employee who did RTW as of claim closure). This result allowed for the null hypothesis that the model's discriminant accuracy is no better than chance alone to be rejected at a level of $p < .05$ (and at a level of $p < .001$). This result also suggested that, according to the general guidelines established by Hosmer et al. (2013, p. 177),

[44] Using the development dataset, the full main and first-order interaction effects model had a *c*-statistic of .881 and the full main effects only model had a *c*-statistic of .817. The most parsimonious main effects only model (at a level of $p < .001$) had a *c*-statistic of .816.

the optimal RTW model had "excellent" discriminant ability (i.e., $.80 \leq AUC < .90$) when applied to the development dataset.

In addition to calibration and discrimination, measures of overall predictive performance are sometimes used to offer supplemental information about a model's fitness. Perhaps the most common are effect size measures which capture calibration *and* discrimination aspects of a model. In logistic regression, effect size measures are analogs to R^2 in multiple linear regression. These measures are thus known as pseudo-R^2 measures and only approximate rather than duplicate the variance interpretation of R^2 in linear regression. The optimal RTW model had a Nagelkerke R^2 equal to .375 (and a corresponding Cox and Snell R^2 equal to .275) when applied to the development dataset.[45] Though model comparisons must be made with great caution given variations in methodology (including regression type and measure used), this effect size measure was somewhat higher than the median explained variance (27%) of the predictive models that were developed in the studies that comprised this researcher's literature review. The optimal RTW model's overall performance measures offer yet further evidence that its predicted outcomes do adequately fit the observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

- Research question 4: How good is the optimal RTW model at classifying a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
    - Hypothesis 4: The ability of the optimal RTW model to classify a development dataset of claims of injured employees who sustained permanent impairment and

[45] Using the development dataset, the full main and first-order interaction effects model had a Nagelkerke R^2 of .530 and the full main effects only model had a Nagelkerke R^2 of .373. The most parsimonious main effects only model (at a level of $p < .001$) had a Nagelkerke R^2 of .366.

received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Given the binary nature of this study's RTW outcome, any predictive model should be able to correctly classify the claims of injured employees comprising the accessible population according to their RTW status as of claim closure *at least* one-half of the time. Further, when considering that 62.3% (4,762 out of 7,648) of all claims of injured employees included in the development dataset had a positive RTW result (i.e., RTW as of claim closure), a useful model's predicted outcomes must match observed outcomes more frequently than this base rate. As presented in Table 13, the optimal RTW model had an overall correct classification rate of 74.9% (5,727 out of 7,648) when applied to the development dataset.[46] This indicated that the model was able to accurately predict whether an injured employee (who sustained permanent impairment and received VR services) whose workers' compensation claim was included in the development dataset did or did not RTW approximately three-fourths of the time.

Table 13

Classification Accuracy of the Optimal RTW Model when Applied to the Development Dataset

	Predicted		
Observed	RTW	No RTW	Percent Correct
RTW	3,901	861	81.9
No RTW	1,060	1,826	63.3
Overall Percent Correct			74.9

Note. The cut-off value between a positive (RTW) and negative (no RTW) prediction is 0.5.

[46] Using the development dataset, the overall classification rates of the full main and first-order interaction effects model and the full main effects only model were 80.6% and 74.6%, respectively. Additionally, the overall classification rate of the most parsimonious main effects only model (at a level of $p < .001$) was 74.6%.

While this overall classification rate verified that the optimal RTW model was able to correctly classify this study's development dataset better than chance alone (and better than sole reliance on the base rate), additional statistical measures were taken to evaluate the validity of the model's predicted probabilities. Two of these measures were sensitivity and specificity. With a cutoff value of .50, the development dataset's optimal RTW model had a sensitivity rate of 81.9% and a specificity rate of 63.3%.[47] This sensitivity rate signified that the model was able to correctly identify nearly five out of six cases in the development dataset with a positive RTW outcome. The model's specificity rate indicated that it was able to correctly identify nearly two out of three cases in the development dataset with a negative RTW outcome. Knowledge of the optimal RTW model's sensitivity and specificity rates revealed that its false negative rate (18.1%) was much lower than its false positive rate (36.7%). The model was thus much more likely to falsely conclude that an injured employee whose claim was part of the development dataset would RTW than that he or she would not RTW. This is a desirable characteristic for a predictive model of RTW outcomes in that when an inaccurate prediction occurs it is preferable to falsely assume that an injured employee who sustained a permanent impairment did possess RTW potential (and thus would presumably receive VR services) rather than to falsely assume that an injured employee who sustained permanent impairment did not possess RTW potential (and thus would presumably not receive VR services).

In assessing the accuracy of a predictive model, it is noteworthy that inflated performance estimates can occur when a dataset is imbalanced with respect to the outcome (Brodersen, Ong,

[47] Theoretically, the best cutoff value (i.e., the cutoff point that maximizes a predictive model's sensitivity and specificity) was approximately .393. At this cutoff value, the sensitivity rate was 70.5% and the specificity rate was 79.6%. However, it is presumably more important that this study's optimal RTW model have a higher level of sensitivity than specificity (i.e., a false negative prediction would be more undesirable than a false positive prediction). Therefore, applying a cutoff value of .50 (relative to the theoretically ideal cutoff value) would likely increase the model's clinical usefulness.

Stephan, & Buhmann, 2010). Because this study's development dataset was somewhat imbalanced (i.e., 62.3% of cases did RTW and 37.7% of cases did not RTW), the optimal RTW model's balanced accuracy was calculated. The model's balanced accuracy, which is the arithmetic mean of its sensitivity and specificity rates, was 72.6%. Therefore, even when adjusting for the imbalance within the development dataset, the optimal RTW model's accuracy remained much better than what would be expected when relying on chance (or the base rate) alone.

Two additional measures that yield important information about the quality of a predictive model are positive and negative predictive values. Using the cutoff value of .50, the optimal RTW model's positive predictive value (PPV) was 78.6% and its negative predictive value (NPV) was 68.0%. The PPV of 78.6% indicated that just under four-fifths of claims of injured employees who were predicted to have a positive RTW outcome did in fact RTW as of claim closure. Likewise, the NPV of 68.0% meant that just over two-thirds of claims of injured employees who were predicted to have a negative RTW outcome failed to RTW as of claim closure. Finally, as a model's precision is determined by its PPV, the development dataset's optimal RTW model appears to be slightly more precise than accurate in its ability to predict the RTW status as of claim closure of claims of injured employees who sustained permanent impairment and received VR services.

Model validation.

- Research question 5: How good is the optimal RTW model at classifying a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?

- Hypothesis 5: The ability of the optimal RTW model to classify a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Prior to answering this research question, an assessment of the significance and the magnitude of the relationship between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes was conducted.[48] A chi-square test of independence revealed that the association between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes was statistically significant, χ^2 (1, N = 7,724) = 1,564.419, $p < .001$. Given this result, the assumption that the predicted probabilities derived from the optimal RTW model and the observed outcomes within the validation dataset were independent from one another was rejected. A phi coefficient (φ) of .45 (which was also statistically significant at a level of $p < .001$) suggested that the magnitude of the relationship was relatively strong.[49] Specifically, according to the guidelines established by Cohen (1988), a phi coefficient of this magnitude corresponds to effects that can be described as medium (.30) to large (.50).

After confirming the relationship between the optimal RTW model's predicted probabilities and the validation dataset's observed outcomes, the model's clinical usefulness (as well as its internal validity) was evaluated. Of particular interest was the optimal RTW model's

[48] It was assumed that injured Minnesota employees whose claims were included in the validation dataset would RTW by claim closure if their predicted probability of failure to RTW by claim closure was less than .50. Likewise, it was assumed that those with a predicted probability of failure to RTW by claim closure of 0.50 or more would not RTW by claim closure.

[49] This phi coefficient can be calculated by taking the square root of the result of dividing the Pearson chi-square statistic (1,564.419) by the size of the validation dataset (7,724).

ability to produce results when applied to the validation dataset similar (in terms of classification accuracy) to those obtained when originally applied to the development dataset. As presented in Table 14, the optimal RTW model was able to correctly classify 74.4% (5,750 out of 7,724) of injured Minnesota employees whose claims were included in this study's validation dataset. This overall classification rate was nearly identical to the one obtained when the model was applied to the development dataset (i.e., 74.9%) and demonstrated that the optimal RTW model was able to accurately predict whether an injured employee (who sustained permanent impairment and received VR services) whose workers' compensation claim was included in the validation dataset did or did not RTW by claim closure nearly three-fourths of the time. Beyond the optimal RTW model's overall classification rate, with a cutoff value of .50, the model had a sensitivity rate of 81.3% (with a false negative rate of 18.7%) and a specificity rate of 63.2% (with a false positive rate of 36.8%). In addition, at the same cutoff point, the model's balanced accuracy was 72.3%. The model also had a PPV of 78.5% and a NPV of 67.1%. These classification measures confirmed that the optimal RTW model is significantly better than chance (and the base rate) alone with respect to its ability to precisely and accurately predict the RTW status as of claim closure of injured employees who sustained permanent impairment and

Table 14

Classification Accuracy of the Optimal RTW Model when Applied to the Validation Dataset

	Predicted		
Observed	RTW	No RTW	Percent Correct
RTW	3,911	901	81.3
No RTW	1,073	1,839	63.2
Overall Percent Correct			74.4

Note. The cut-off value between a positive (RTW) and negative (no RTW) prediction is 0.5.

received VR services.[50] These results also completed the split dataset validation process and offered compelling evidence that the optimal RTW model possesses a high degree of internal validity (i.e., given the close resemblance in classification accuracy when applied to both datasets[51]).

Consideration of Practical Issues

Each of the six practical issues that Tabachnick & Fidell (2007) indicated could pose potential problems in a logistic regression analysis were evaluated. As previously noted, these practical issues relate to the following: 1) ratio of cases to variables; 2) adequacy of expected frequencies and power; 3) linearity in the logit; 4) multicollinearity; 5) outliers in the solution; and 6) independence of errors. First, with respect to the ratio of cases to variables, events per variable (EPV) values of 97 for events (RTW as of claim closure) and 59 for non-events (no RTW as of claim closure) were obtained when applying the optimal RTW model to the development dataset. Similarly, EPV values of 98 for events and 59 for non-events were obtained when applying the optimal RTW model to the validation dataset. These EPV values easily exceed even the rigorous recommendation of having an EPV value of at least 40 when assessing a model's interval validity via a split-dataset approach. Second, the size of expected frequencies proved adequate as the goals of having all expected frequencies be greater than one and having no more than 20% being less than five were accomplished (e.g., see Table 12 which reveals the expected frequencies for the outcome variable across each decile of risk for failure to

[50] This is corroborated by the optimal RTW model's overall classification rate of 74.7%, its sensitivity and specificity rates of 81.6% and 63.2%, its balanced accuracy of 72.4%, and its positive and negative predictive values of 78.6% and 67.5% when applied to this study's full dataset (i.e., including the development and validation datasets).

[51] The differences in the optimal RTW model's sensitivity and specificity rates, the balanced accuracy, and the positive and negative predictive values when applied to the development and validation datasets were all less than one percent.

RTW as of claim closure in the development dataset). Consequently, with such a large dataset, there were no concerns about a lack of statistical power for this data analysis. Third, a lack of linearity in the logit was not a possible threat to this study as all predictors were discrete. Fourth, as can be seen by reviewing Table 6, multicollinearity among predictors was not a problem as no bivariate correlation exceeded .50. Fifth, an examination of residuals was conducted to search for potential outliers in the development dataset. Cases possessing a standardized residual with an absolute value exceeding three were considered possible outliers and candidates for exclusion from the data analysis. However, as no cases had a standardized residual with an absolute value of this magnitude, no outliers were identified. The optimal RTW model was thus constructed using data from all 7,648 cases included in the development dataset and internally validated using data from all 7,724 cases included in the validation dataset. Sixth, independence of errors was assured as all information came from distinct claims of injured Minnesota employees who sustained permanent impairment and received VR services.

Summary

In this chapter, descriptive and predictive analyses results were presented. Through descriptive analysis, the accessible population was described according to the study's variables of interest. In addition, the predictors (e.g., attorney involvement; severity of permanent impairment) with the strongest bivariate relationship with the outcome were identified. Through predictive analysis, an optimal RTW model was developed and internally validated using a split-dataset validation approach. The results of this validation technique suggest that the model possesses a high degree of internal validity. Optimal RTW model specification consisted of medical (severity of permanent impairment), individual (age), and workplace (attorney involvement; job tenure; pre-injury average weekly wage; pre-injury industry) factors and included four main effects and three first-order interaction effects. Model performance was strong in terms of its goodness-of-fit (as evidenced by its calibration and discriminant ability) and its clinical usefulness (as evidenced by its classification accuracy). Potential uses (and misuses) of this study's optimal RTW model within Minnesota's workers' compensation system are included as part of the discussion of results and presentation of conclusions and recommendations in the following chapter.

Chapter 5: Summary and Conclusions

Introduction

This chapter begins with a study summary that is comprised of the following: problem overview; purpose statement and research questions; methodology review; major findings. Study results are then related to existing literature on the prediction of RTW outcomes. This involves a comparison of the outcomes of this study with the findings from the critical review that are presented in Chapter 2. After placing this study's results in the context of prior RTW research, conclusions are drawn regarding the practical significance (i.e., clinical usefulness) of the optimal RTW model in Minnesota's workers' compensation system. Included among these conclusions are implications for action (e.g., discussion of potential uses and misuses of the optimal RTW model), recommendations for further research (e.g., offering of guidance about what additional information may be useful in improving this study's optimal RTW model) and concluding remarks (e.g., statement about the intended benefits of this study).

Problem Overview

In Minnesota's workers' compensation system, injured employees who are unable to return to their pre-incident employment (or who are at least having difficulty doing so) may be eligible for receipt of VR services if they are determined to be capable of benefitting from such services. The provision of VR services can be a valuable tool in minimizing work disability by ensuring that an injured employee is able to maximize his or her residual wage-earning capacity (either in his or her pre-incident employment or other employment). However, for VR services to be effective at a system level, it is essential to precisely and accurately identify the rehabilitation potential of injured employees (i.e., determining which injured employees who need assistance to re-enter the workforce are most and least likely to RTW). Failure to do so is almost certain to result in the misallocation of a scarce and costly resource.

Unfortunately, it appears that the current method of determining which injured Minnesota employees are qualified for VR benefits is inadequate in assessing RTW (and thus rehabilitation) potential. The deficiencies in the existing selection process, which relies on the clinical judgment of qualified rehabilitation consultants, are evidenced by several recent trends pertaining to the provision of VR services within Minnesota's workers' compensation system (Berry & Zaidman, 2013). From the late 1990s through 2010, there was an increase in the percentage of injured employees with indemnity claims who were deemed eligible for VR benefits (15.3% in 1997 to 23.8% in 2011). Concomitant with this increase in service provision was an increase in mean VR service costs per participant ($7,220 per participant in 1998 to $8,830 per participant in 2011[52]) and a decrease in the percentage of VR participants who reported having a job at [rehabilitation] plan closure (71.5% in 1998 to 54.5% in 2011). Thus, while the VR participation rate rose 55.6%, service costs per VR participant increased 22.3% and RTW rates among VR participants declined 23.8%. Further, data collected by the Minnesota DLI reveals that in 2011 mean VR service duration was significantly longer for those who did not RTW (i.e., 12.1 months for those who did RTW and 16.8 months for those who did not RTW) and that mean VR service costs were considerably higher for those who did not complete

[52] These average service cost per participant figures are adjusted for wage growth according to the annual change in Minnesota's statewide average weekly wage. Hence, both figures are presented in 2011 dollars.

their VR plan (i.e., $6,280 for those who did complete their plan and $12,480 for those who did not complete their plan) (Berry & Zaidman, 2013).

These statistics suggest the existence of outliers among VR participants who, despite receiving extensive VR services (in terms of duration and cost), are not returning to work. The existence of outliers among VR participants is also supported by the fact that mean service duration and costs consistently and significantly exceeded median service duration and costs between 1998 and 2011. This indicates that the distribution of VR service duration and costs during this time period was positively-skewed with a relatively small percentage of VR participants (who are more often than not failing to RTW as of claim closure) taking up a significant portion of VR resources in terms of time and money. For example, considering this study's accessible population, 10,425 claims (67.8% of all claims) had VR service costs of $10,000 or less (with a mean VR service cost of $4,479) and 1,891 claims (12.3% of all claims) had VR service costs of $20,000 or more (with a mean VR service cost of $31,008). The RTW rate for those with VR service costs of $10,000 or less was 70.0% while the RTW rate for those with VR service costs of $20,000 or more was 43.8%. This data raises concerns about the uncertain reliability of the inherently subjective clinical judgment process that is used to determine the VR benefit eligibility status of injured Minnesota employees. It is clear that, in order to improve the consistency of the VR eligibility decision-making process (and to avoid any associated resource misallocation), an objective, evidence-based method of predicting the RTW outcomes of injured Minnesota employees prior to service provision is needed. This study was constructed with the purpose of meeting this need.

Purpose Statement and Research Questions

In conjunction with the goal of developing a mechanical prediction method to enhance Minnesota's VR eligibility determination process for injured employees, this study had the following purpose: to identify the most parsimonious set of rehabilitation outcome explanatory variables (including medical, individual, and workplace factors) that precisely and accurately predicts the RTW status as of claim closure of injured employees who sustained permanent impairment and received VR services in Minnesota's workers' compensation system. Accomplishing this objective allowed this researcher to construct a RTW outcomes model using predictive analytics that was able to effectively discriminate between injured Minnesota employees who are and who are not likely to RTW. Given the optimal RTW model's discriminant ability, study results can offer meaningful assistance to decision-makers (e.g., qualified rehabilitation consultants) responsible for determining which injured Minnesota employees possess RTW potential and can benefit from receipt of VR services. In addition, study results can help workers' compensation policy makers (e.g., Minnesota state legislators) by identifying vulnerable populations of injured employees with low RTW rates despite receipt of VR services in their current form.

To achieve this study's purpose, five research questions and associated hypotheses were formulated to provide guidance for the modeling process (including development and validation). These research questions and associated hypotheses are identified below:

Model development.

- Research question 1: Does knowledge of the full set of RTW outcome predictor variables make a difference in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?

 - Hypothesis 1: Knowledge of the full set of RTW outcome predictor variables does make a difference (i.e., is helpful) in predicting RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

- Research question 2: Can a more parsimonious RTW model be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
  - Hypothesis 2: A reduced RTW model can be developed that is not reliably different from the full RTW model in its ability to predict the RTW status as of claim closure in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.
- Research question 3: How well does the optimal RTW model (i.e., the most parsimonious model that reliably predicts the outcome) fit observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services?
  - Hypothesis 3: Predicted RTW outcomes from the optimal RTW model are not significantly different from observed RTW outcomes in a development dataset of claims of injured employees who sustained permanent impairment and received VR services.

- Research question 4: How good is the optimal RTW model at classifying a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
    - Hypothesis 4: The ability of the optimal RTW model to classify a development dataset of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Model validation.

- Research question 5: How good is the optimal RTW model at classifying a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known?
    - Hypothesis 5: The ability of the optimal RTW model to classify a validation dataset (rather than a development dataset) of claims of injured employees who sustained permanent impairment and received VR services for which actual RTW outcomes are known is better than chance (and the base rate) alone.

Methodology Review

Stemming from a biopsychosocial perspective of disability, this study was designed to evaluate the relationship between a set of medical, individual, and workplace factors and the RTW status at claim closure of injured employees in Minnesota who sustained work-related permanent impairment and subsequently received VR services. Specifically, the research aim of developing and validating a predictive model of the RTW potential of this subset of injured Minnesota employees was achieved by employing a closed-claim, retrospective design. Data for this cross-sectional study was obtained from the statewide workers' compensation database that is maintained by the Minnesota DLI. The accessible population included all injured employee indemnity claims that were contained in this administrative claims database and that satisfied all eligibility criteria (e.g., claim filed between January 1, 2003 and December 31, 2011; claim closed by September 30, 2012; evidence of permanent impairment; receipt of VR services).[53] Of the 214,122 claims that met the first eligibility criterion of being filed between 2003 and 2011, 15,372 claims met all remaining criteria necessary for study inclusion. It was these 15,372 claims of injured employees that comprised the accessible population and that were included in this RTW outcomes study.

After identifying the claims to be included in the study, it was necessary to determine what information would be collected about the injured employees who had filed the claims that encompassed the accessible population. Guidance for this variable selection process was initially provided by a critical literature review of rehabilitation research related to the prediction of RTW outcomes. Variable selection was also based on researcher judgment about objective biopsychosocial factors (i.e., including medical and non-medical, or contextual, factors) most likely to influence an injured employee's RTW potential and, ultimately, what information was available from the Minnesota workers' compensation administrative claims database. This selection process eventually led to the collection of the following categorical independent variables (predictors) and dependent variable (outcome): 1) medical factors (nature of injury or illness; part of body affected; severity of permanent impairment; time from date of injury to VR service initiation; pre-existing claim status); 2) individual factors (age; sex; education; marital status; residence); 3) workplace factors (job tenure; pre-injury average weekly wage; attorney

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[53] All eligibility criteria for study inclusion are identified on pages 64 and 65.

involvement; pre-injury occupation; pre-injury industry); and 4) rehabilitation outcome (RTW status as of claim closure). Access to this information set the groundwork for performing a data analysis that culminated in the development and validation of a model that precisely and accurately predicted the RTW status as of claim closure of the injured employees who sustained permanent impairment and received VR services and whose claims were included in this study.

Data analysis was two-pronged and consisted of a descriptive and a predictive analysis. The primary intent of descriptive analysis was to describe the study's accessible population according to the variables of interest (univariate analysis) and to assess the relationships between study variables (bivariate analysis). Predictive analysis was performed in order to establish the extent of the relationship between this study's RTW outcome and its set of predictors. The statistical technique used to complete this predictive analysis was binary logistic regression. The analysis included the use of standard and stepwise logistic regression. Standard logistic regression was first employed to confirm the existence of a meaningful association between the full set(s) of predictors (including a full set of main and first-order interaction effects and a full set of main effects only) and the RTW status as of claim closure of this study's accessible population. Backward stepwise logistic regression was then applied to determine whether the full model(s) could be reduced without relinquishing predictive power. When applying this stepwise method, variable retention for reduced models was based on the increasingly stringent alpha levels of .157, .05 and .001. Subsequent to this model development process, model comparisons (e.g., between full and reduced models) were made according to specification and performance. The most parsimonious set of predictors that reliably predicted RTW status as of claim closure among this study's development dataset (and ultimately the validation dataset) was selected as the optimal predictive model.

In addition to developing an optimal RTW model, the internal validity of the model was evaluated with a split-dataset (approximately 50%:50%) validation approach. This involved the random splitting of the full dataset into a development and a validation dataset. After completion of the model building process using the development dataset, the optimal RTW model was applied to the validation dataset. The purpose of this procedure was to assess the optimal RTW model's ability to correctly classify (with respect to RTW status as of claim closure) a population of closed claims of injured Minnesota employees that was related to, but distinct from, the one on which the model was originally constructed. Evidence of a higher degree of internal validity was obtained by achieving similar results in terms of model performance (i.e., classification accuracy) when applying the optimal RTW model to the split datasets.

Major Findings

Descriptive analysis results revealed that 62.3% (9,574 out of 15,372) of the claims included in the accessible population were filed by injured employees who did successfully RTW as of claim closure. There were six predictor variables (including two medical factors, one individual factor, and three workplace factors) that had more than a *negligible* association with this RTW outcome. These predictors included attorney involvement (φ_c = .46), severity of permanent impairment (φ_c = .43), job tenure (φ_c = .16), pre-injury average weekly wage (φ_c = .14), part of body affected (φ_c = .12), and education (φ_c = .12). The relationships between this study's RTW outcome and these six predictors indicated that, *ceteris parabus*, risk factors for failure to RTW by claim closure among the accessible population include the following: 1) attorney involvement; 2) higher level of permanent impairment; 3) shorter job tenure (with pre-injury employer); 4) lower pre-injury average weekly wage; 5) injury affecting the head and neck (including throat) or the back (including spine and spinal cord); and 6) lower level of educational attainment.

Predictive analysis results confirmed the existence of a relationship between this study's set of biopsychosocial factors (including medical, individual, and workplace factors) and the RTW status at claim closure of injured employees in Minnesota who sustained permanent impairment and received VR services. Predictive analysis results also demonstrated that the full set of predictor variables could be reduced to seven variables (including four main effects and three first-order interaction effects) that remained significantly associated with, and able to reliably predict, the accessible population's RTW status at claim closure (at a *p*-value of .001). These seven variables, which constitute the optimal RTW model, include one medical factor (severity of permanent impairment), one individual factor (age), two workplace factors (job tenure; attorney involvement), one interaction between a workplace factor and a medical factor (attorney involvement X severity of permanent impairment), and two interactions between workplace factors (attorney involvement X job tenure; pre-injury average weekly wage X pre-injury industry). The logistic regression prediction equation for this optimal RTW model is as follows:

log(p/1-p) = -2.951 + 2.014(Attorney involved) – 0.073(6% to 10% PI) – 0.475(11% to 15% PI) + 0.016(16% to 20% PI) + 0.467(21% PI or more) + 2.371(Unknown PI) + 0.268($500 or less X Natural resources and mining) + 0.989($500 or less X Construction) + 0.554($500 or less X Manufacturing) + 0.466($500 or less X Trade, transportation and utilities) + 0.319($500 or less X Information) + 0.622($500 or less X Financial activities) + 0.622($500 or less X Professional and business services) + 0.322($500 or less X Education and health services) + 0.595($500 or less X Leisure and hospitality) + 1.002($500 or less X Other services) – 0.158($501 to $750 X

Natural resources and mining) + 0.580($501 to $750 X Construction) + 0.344($501 to $750 X Manufacturing) + 0.322($501 to $750 X Trade, transportation and utilities) – 0.067($501 to $750 X Information) – 0.030($501 to $750 X Financial activities) + 0.361($501 to $750 X Professional and business services) – 0.094($501 to $750 X Education and health services) + 0.181($501 to $750 X Leisure and hospitality) + 0.315($501 to $750 X Other services) + 0.223($751 to $1,000 X Natural resources and mining) – 0.003($751 to $1,000 X Construction) – 0.097($751 to $1,000 X Manufacturing) + 0.150($751 to $1,000 X Trade, transportation and utilities) + 0.683($751 to $1,000 X Information) + 0.078($751 to $1,000 X Financial activities) – 0.192($751 to $1,000 X Professional and business services) – 0.288($751 to $1,000 X Education and health services) + 0.300($751 to $1,000 X Leisure and hospitality) – 0.429($751 to $1,000 X Other services) + 0.237(25 to 34 years) + 0.351(35 to 44 years) + 0.563(45 to 54 years) + 0.899(55 to 64 years) + 1.008(Less than 1 year) + 0.269(1 to 5 years) + 0.018(Attorney involved X 6% to 10% PI) + 0.552(Attorney involved X 11% to 15% PI) + 0.476(Attorney involved X 16% to 20% PI) – 0.024(Attorney involved X 21% PI or more) – 1.091(Attorney involved X Unknown PI) – 0.837(Attorney involved X Less than 1 year) – 0.283(Attorney involved X 1 to 5 years), where p is the probability of RTW as of claim closure. Extending this equation, $\hat{Y}_i$, which represents the probability of failure to RTW as of claim closure, is calculated as follows: $\hat{Y}_i = e^u/(1+e^u)$, where $\hat{Y}_i$ is the estimated probability that the *i*th claim ($i = 1, \ldots, n$) was filed by an injured employee who did not RTW as of claim closure and *u* is the usual linear regression equation: $u = A + B_1X_1 + B_2X_2 + \ldots + B_kX_k$, with constant A, coefficients B_j, and predictors X_j for *k* predictors ($j = 1,2, \ldots, k$) (Tabachnick & Fidell, 2007, p. 438).

Assessment of the optimal RTW model's performance suggests that it possesses high degrees of *goodness-of-fit* (as measured by its calibration, discrimination and overall performance) and *clinical usefulness* (as measured by its classification accuracy). Regarding goodness-of-fit, evidence of the optimal RTW model being well-calibrated was initially obtained with statistically insignificant H-L test result, χ^2 (8, N = 7,468) = 10.617, p = .224. Further testing of model calibration was performed to ensure that an informed decision about model fit was made. One crude calibration measure was to compare the frequencies of predicted and observed outcomes across each decile of risk of failure to RTW as of claim closure for both outcome groups (see Table 12). It was apparent from reviewing these frequencies that the predicted and observed outcomes across each risk decile for claims of injured employees who did and who did not RTW were quite similar. A more refined calibration measure was obtained by performing a linear regression of predicted and observed risk decile means. The linear regression line had a slope of 0.999 and an intercept term of 0.441 which proved to be not statistically significantly different than zero, t(19) = 0.076, p = .940 (see Figure 4). These regression line characteristics demonstrated a close correspondence to the 45-degree line of perfect fit and were strong indicators of a well-calibrated model. It is therefore reasonable to conclude that the optimal RTW model is sufficiently calibrated for it to be of prognostic value in assessing RTW (and rehabilitation) potential within Minnesota's workers' compensation system (depending on its performance in relation to other aspects of goodness-of-fit and clinical usefulness).

In addition to calibration, the optimal RTW model's goodness-of-fit was assessed according to its discriminant ability and overall performance. The model's discriminant ability was measured by its AUC, or *c*-statistic, which was .818, 95% CI [.808, .828]. This *c*-statistic signified that there is an 81.8% chance that a randomly selected claim filed by an injured employee who did not RTW as of claim closure would have a higher predicted probability of failure to RTW than a randomly selected claim filed by an injured employee who did RTW as of claim closure. It also suggested that the model possesses “excellent” discriminant accuracy (Hosmer et al., 2013) and allowed for the null hypothesis that the model’s discriminant accuracy is no better than chance alone to be rejected at a level of $p < .001$. The optimal RTW model’s overall performance was evaluated using measures of its effect size. In particular, the model had a Nagelkerke R^2 of .375 and a corresponding Cox and Snell R^2 of .275. These pseudo-R^2 measures offered further support of the relationship between the optimal RTW model’s predictor variables and the accessible population’s RTW status as of claim closure. Taken in combination with the previously described findings regarding the model’s calibration and discrimination, these effect size measures strongly suggest that there is a high level of fit between predicted and observed RTW outcomes in this study’s development dataset of claims of injured employees who sustained permanent impairment and received VR services.

Regarding clinical usefulness, the optimal RTW model had an overall classification rate of 74.7% (11,477 out of 15,372) when applied to the full dataset. This model was thus able to accurately predict the accessible population’s RTW status as of claim closure nearly three-fourths of the time. This overall classification rate was a significant improvement over classifying cases according to chance (7,686 out of 15,372) or the base rate (9,574 out of 15,372) alone. Additionally, with a cutoff value of .50, the model had a sensitivity rate of 81.6% (with a false negative rate of 18.4%) and a specificity rate of 63.2% (with a false positive rate of 36.8%). Applying this same cutoff point, the model had a balanced accuracy of 72.4%, a PPV of 78.6% and a NPV of 67.5%. These classification results suggest that, while slightly more precise than accurate, the optimal RTW model is clinically useful as an objective, evidence-based method of predicting (prior to the provision of VR services) the RTW status as of claim closure of injured Minnesota employees who have sustained permanent impairment.

The internal validity of this study's optimal RTW model was evaluated, and ultimately established, using a split-dataset validation approach. Evidence of the predictive model's internal validity was provided by the reproducibility of model performance (specifically with respect to classification accuracy) when applying the model to the split datasets (including a development dataset and a validation dataset). For instance, the optimal RTW model's overall classification rate was 74.9% (5,727 out of 7,648) when applied to the development dataset and 74.4% (5,750 out of 7,724) when applied to the validation dataset. Additionally, the differences in the optimal RTW model's sensitivity and specificity rates, balanced accuracy, and positive and negative predictive values when applied to the split datasets were all less than one percent (e.g., sensitivity rate of 81.9% in the development dataset and 81.3% in the validation dataset). This lends strong support for the conclusion that the optimal RTW model possesses a high degree of internal validity and that it is a useful tool for predicting the RTW status as of claim closure of this study's target population.

Model Selection

Selecting the optimal RTW model involved consideration of model specification (and associated complexity) in addition to model performance. Accordingly, beyond performance measures related to calibration, discrimination, overall performance, and clinical usefulness, full and reduced models were compared in terms of their degrees of freedom. The added predictive capacity associated with including first-order interaction effects in a model was also weighed against the concurrent increase in model complexity. It is noteworthy that if the selection process was based strictly on model performance, the full main and first-order interaction effects model would clearly be chosen given its superior ability to precisely and accurately predict the RTW status as of claim closure of injured Minnesota employees who sustained permanent impairment and received VR services. This is evidenced with a review of Table 15 which contains measures related to the four previously mentioned performance aspects for the full and reduced (at a level of $p < .001$) main and first-order interaction effects and main effects only models. However, the full main and first-order interaction effects model would not likely be practically useful given that it has 1,127 degrees of freedom. This is in comparison to the reduced main and first-order interaction effects model and the full main effects only model which have 49 degrees of freedom and the reduced main effects only model which has 25 degrees of freedom. Thus, when taking into account model complexity, the three models with the greatest potential to be practically useful were the reduced main and first-order interaction effects model and the full and reduced main effects only models. With respect to the main effects only models, though the reduced model was less complex than the full model (e.g., including 6 rather than 15 main effects), its performance measures were slightly inferior regarding calibration and discrimination (and consequently overall performance). Meanwhile, the reduced main and first-order interaction effects model had an identical number of degrees of freedom as the full main effects only model but had somewhat better measures regarding calibration, overall performance, and clinical usefulness. Additionally, beyond the calibration slope, it was apparent that first-order interaction effects did improve the model's calibration as significant H-L test results were obtained when considering main effects only (whereas non-significant H-L test results were obtained when considering main and first-order interaction effects). This led to the conclusion that, when considering the trade-off between model

Table 15

Summary of Performance Measures of Full and Reduced Main and First-Order Interaction Effects and Main Effects Only Models Using the Development Dataset

Aspect	Measure	Main and First-Order Interaction Effects		Main Effects Only	
		Full	Reduced	Full	Reduced
Calibration	Calibration slope[a]	1.000	0.999	0.996	0.992
Discrimination	*c*-statistic	.881	.818	.819	.816
Overall Performance	Nagelkerke R^2	53.0%	37.5%	37.3%	36.6%
Clinical Usefulness	Overall classification rate	80.6%	74.9%	74.6%	74.6%

[a] For each model, the calibration slope was derived by performing a linear regression of predicted and observed decile means of claims of injured employees who did and who did not RTW as of claim closure.
[b] Reduced models were determined using an alpha level of $p < .001$.

complexity and performance, it was appropriate to designate the reduced main and first-order interaction effects model (at a level of $p < .001$) as this study's optimal RTW model.

Findings Related to the Literature

The critical literature review that was conducted in order to provide guidance for the methodology of this study made clear that [work] disability is a multifactorial construct that is best evaluated from a biopsychosocial rather than a biomedical perspective. Findings from this study add further support for disability being a function of medical *and* non-medical factors. In fact, all but one of the factors included in the optimal RTW model were non-medical, or contextual (i.e., individual and workplace), factors. The one medical factor that was retained in the optimal RTW model was severity of permanent impairment. This is consistent with disablement models (e.g., Nagi's model; WHO's ICF model) which propose that disability is a potential consequence of impairment. However, more importantly, study results are also concordant with prior rehabilitation research in revealing that impairment is a necessary but insufficient predictor of disability. That is, when determining the extent to which an injury or illness has impacted an employee's ability to return to suitable gainful employment, contextual factors that influence the interaction between an employee and his or her work environment must be considered. Among the accessible population of claims filed by injured employees who sustained permanent impairment and received VR services, these contextual factors included the individual factor of age (and to some extent education[54]) and the workplace factors of job tenure, pre-injury average weekly wage, attorney involvement, and pre-injury industry. In this section, this study's findings with regard to each of these disability determinants (including the medical

[54] Though education was not retained in the optimal RTW model, it was one of six predictors with a bivariate relationship with RTW status as of claim closure that can qualitatively be described as more than negligible.

factors of severity of permanent impairment and part of body affected[55]) are related to existing literature on the prediction of RTW outcomes. This discussion is structured according to the relative importance of each of these disability determinants (or RTW predictors) within the optimal RTW model (as well as the most parsimonious main effects only model).[56] Accordingly, given their absence from the optimal RTW model, part of body affected and education are discussed at the conclusion of this section.

Attorney involvement.

The workplace factor attorney involvement proved to be the primary predictor of RTW status as of claim closure among the development dataset. Perhaps the best indicator of its importance was the wide variation in the RTW rates of injured employees whose claims comprised this study's accessible population. While nearly seven out of eight (86.8%) injured employees without legal representation did RTW as of claim closure, nearly six out of ten (58.2%) injured employees with legal representation did not accomplish this goal. Additionally, considering main effects only, injured employees who retained an attorney were 5.55 times more likely to have failed to RTW as of claim closure than their counterparts who did not retain an attorney, *ceteris parabus*.[57] Though the finding that injured Minnesota employees represented by an attorney were less likely to RTW is not surprising given the results of previous research (Blackwell et al., 2003; Butterfield et al., 1998; Gumerman, 1998; Pransky et al., 2006), the magnitude of the relationship between attorney involvement and this study's RTW outcome does raise intrigue about the possible reason(s) for this correlation. Presuming that attorney

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[55] Like education, though part of body affected was not retained in the optimal RTW model, it was one of six predictors with a bivariate relationship with this study's RTW outcome that was more than negligible.

[56] The Wald χ^2 statistic was used to determine the relative importance of each predictor retained in the optimal RTW model (and the reduced main effects only model).

[57] This odds ratio increased to 7.49 when taking first-order interaction effects into account.

involvement is not the primary cause of (and merely a risk factor for) work disability, what is of particular interest is the signal being sent when an injured employee elects to retain an attorney. The Workers' Compensation Research Institute (WCRI) recently conducted a study that included 11 states and that involved a review of 6,823 claims records of injured employees who had accumulated over seven days of lost work time.[58] As part of the study, injured employees who were two to three years post-incident were interviewed by telephone to determine why they had sought legal representation. Study findings indicated that the primary reasons for attorney involvement were lack of workplace trust (e.g., employee fear of employer retaliation for filing a claim), fear of claim denial, and higher degrees of injury severity (Johnson, 2012). Injured employees who retained an attorney were reportedly also more likely to be older and less educated and to have shorter job tenure (i.e., less than one year) and less specific work-related injuries (e.g., low back condition rather than a fracture).

Though these responses were from injured employees outside of Minnesota, this study's results resemble the WCRI's findings in several key respects. In particular, attorney involvement proved to be significantly associated with the severity of an injured employee's permanent impairment. While only 34.3% (1,505 of 4,383) of injured employees with a whole person permanent impairment rating of 1% to 5% were legally represented, 60.9% (352 of 578) of those with a whole person permanent impairment rating exceeding 20% retained an attorney.[59] Job tenure was also a strong predictor of attorney involvement as 67.0% (2,582 of 3,855) of injured employees with less than one year of experience with their pre-injury employer hired an

[58] These 11 states included Texas, Wisconsin, Pennsylvania, Michigan, Connecticut, Florida, Massachusetts, North Carolina, California, Tennessee and Maryland.

[59] The relationship between attorney involvement and severity of permanent impairment was steady as 39.7% of injured employees with an impairment rating from 6% to 10% were legally represented, 47.4% of those with an impairment rating from 11% to 15% were legally represented, and 55.5% of those with an impairment rating from 16% to 20% were legally represented.

attorney while only 43.1% (2,892 of 6,714) of those with more than five years of experience with their pre-injury employer hired an attorney. Injured employees with between one and five years of tenure with their pre-injury employer involved an attorney in their claim 60.4% (2,902 of 4,803) of the time. Other important correlates of attorney involvement in this study's accessible population were part of body affected, education, and pre-injury average weekly wage. Regarding part of body affected, injured employees who sustained injuries to their head and neck (68.6%) or back (67.0%) retained an attorney at much higher rates than those who suffered injuries to their lower extremities (41.6%) or trunk or body system(s) (43.2%). Regarding education, seven out of ten (70.1%) injured employees with less than a high school education were legally represented while only four out of ten (40.3%) injured employees with a bachelor's degree or more were legally represented. Finally, regarding pre-injury average weekly wage, higher earnings were associated with lower rates of attorney involvement (e.g., 62.0% of injured employees previously earning $500 or less retained an attorney while only 44.2% of those previously earning $1,001 or more retained an attorney).

These correlations suggest that injured Minnesota employees who sustain permanent impairment and receive VR services (and potentially those in other workers' compensation systems) are more likely to hire an attorney when greater uncertainty exists about their ability to return to suitable gainful employment. For example, those with more severe injuries (as measured by severity of permanent impairment) are presumably likely to have more doubt about their ability to RTW than those with less severe injuries. It also seems logical that, irrespective of injury severity, injured employees who are in a tenuous relationship with their employer and/or the labor market are likely to be more skeptical about their RTW prospects following a work-related incident. Injured employees with less than one year of job tenure may perceive themselves as lacking job stability due to not having established a trusting relationship with their employers. Also, those with a less than high school education may perceive themselves as lacking job stability (and more generally labor market stability) given limited access to more than entry-level, high turnover positions in often physically demanding occupations. This uncertainty can be further magnified when a claim involves a head and neck or a back injury which tend to have highly variable outcomes. It is therefore reasonable to conclude that injured employees sharing these characteristics (e.g., more severe permanent impairment; shorter job tenure; less than high school education; head and neck or back injury) are more likely than others to have higher perceptions of the severity of their disability and lower recovery (including RTW) expectations. Further, injured employees who earn lower wages prior to their work-related incident arguably have less incentive to RTW than those with higher wages. This may minimize the RTW motivation of such injured employees and contribute to self-defeating behavior due to secondary gain, especially if their indemnity benefits (from workers' compensation or other social insurance programs) are comparable to their pre-incident earnings. Thus, a plausible explanation for the strength of the relationship between attorney involvement and the RTW status as of claim closure among the accessible population is that the factors which increase the likelihood that injured employees will hire an attorney also adversely affect certain individual psychosocial characteristics (e.g., perception of the severity of disability; recovery expectations; RTW motivation) that are well known to influence RTW outcomes (e.g., Heymans et al., 2006; Pransky et al., 2006; Schultz et al., 2002).

In considering possible reasons for the significant link between attorney involvement and RTW status as of claim closure in Minnesota's workers' compensation system, it is important to be mindful of the perspectives of disability stakeholders who are part of the RTW process.

Examples of disability stakeholders include injured employees and their families and dependents, employers, insurers, coworkers, labor unions, legal representatives, and health care providers (Young et al., 2005). In the case of legal representatives, particularly those representing injured employees, their incentives may not always be aligned with the vocational goal of successful return to suitable gainful employment. As is common in workers' compensation systems, attorneys representing injured Minnesota employees are paid on a contingency basis. Specifically, the current fee for injured employee attorneys is "20% of the first $130,000 of compensation awarded to the employee" resulting in a maximum fee of $26,000 (Minnesota Statutes 2013, 176.081, subdivision 1a).[60] This clearly reveals that, while there is surely variation in the extent to which injured employee attorneys are supportive of their client's RTW efforts, they possess a monetary motivation that has the potential to conflict with the desirable outcome of RTW as of claim closure. A reasonable inference when taking this contextual factor (i.e., attorney motivations) into account is that attorneys attempting to legally prove their client's work-related disability often serve to reinforce the psychosocial characteristics (e.g., poor RTW expectations) that adversely affect RTW outcomes and that may contribute to the injured employee's initial decision to retain an attorney.

Severity of permanent impairment.

Though severity of permanent impairment was the only medical factor included in the optimal RTW model, it did prove to be the second most important predictor of RTW status as of claim closure among this study's development dataset. The bivariate relationship between severity of permanent impairment and this study's RTW outcome demonstrated that injured

[60] Though the formula for determining attorney fees was different during the relevant period for this study (i.e., 2003 through 2011), injured employee attorneys were still paid on a contingency basis. Prior to the legislative change regarding attorney fees in 2013, injured employee attorneys were entitled to 25% of their client's first $4,000 in compensation and 20% of their client's next $60,000 in compensation resulting in a maximum fee of $13,000.

employees with higher levels of impairment were less likely to return to gainful employment as of claim closure. Among those with a known impairment rating, of particular relevance with regard to predicting the outcome was whether an injured employee had a permanent impairment rating of greater than 15%. Considering main effects only, *ceteris parabus*, injured employees with a permanent impairment rating (i.e., to the whole person) of 16% to 20% were 1.44 times more likely to fail to RTW as of claim closure than those with a permanent impairment rating of 1% to 5%. Additionally, *ceteris parabus*, those with a permanent impairment rating of 21% or more were 1.56 times more likely to fail to RTW as of claim closure than those with a permanent impairment rating of 1% to 5%.

The finding that injured employees who possess higher levels of permanent impairment (particularly those with permanent impairment ratings over 15%) have lower RTW rates in Minnesota's workers' compensation system is consistent with prior rehabilitation research which suggests that there is an inverse relationship between injury severity and employment status (Brouwers et al., 2009; Holtslag et al., 2007; Krause et al., 1998; Kreutzer et al., 2003). This association between *impairment* (as measured by severity of permanent impairment) and *disability* (as measured by RTW status as of claim closure) is also in accordance with disablement models such as those developed by Nagi (1965) and, more recently, the WHO (2001). That is, injured employees with higher (rather than lower) levels of permanent impairment are more likely to possess functional limitations that adversely affect their ability to find and maintain employment in a competitive work environment. However, what neither existing rehabilitation research nor disablement models can offer guidance about is the sharp contrast in the RTW rates of injured employees with and without a known permanent impairment rating. The reasoning behind this occurrence is worthy of investigation as 74.0% (8,564 out of

11,568) of those with a known impairment rating did RTW as of claim closure while only 26.6% (1,010 out of 3,804) of those without a known impairment rating achieved this same goal. In harmony with these RTW rates, *ceteris parabus*, injured employees with an unknown permanent impairment rating were 3.85 times more likely to fail to RTW than those with a permanent impairment rating of 1% to 5%.

Fortunately, it appears that the relationship between knowledge of an injured employee's impairment rating and his or her RTW status as of claim closure can be explained in great part with the assistance of this study's most salient predictor, attorney involvement. This is because while only 41.1% (4,753 out of 11,568) of all members of the accessible population with a known impairment rating retained an attorney, 95.2% (3,623 out of 3,804) of those with an unknown impairment rating were legally represented. One possible explanation for the poor RTW rates among injured employees with an unknown impairment rating is that the lack of specification of an impairment rating is an indicator of a contentious claim in which there is a strained relationship between the injured employee and his or her employer (i.e., adversarial environment creating a RTW barrier). A second possible explanation is that injured employees with an unknown impairment rating may be more likely to possess individual psychosocial characteristics (e.g., perception of high levels of disability; low recovery expectations; poor RTW motivation) that are associated with undesirable RTW outcomes. Finally, given that the claims without an identified impairment rating that were a part of this study all involved a claim settlement of at least $20,000 that likely included consideration of a compromised PPD award (B. Zaidman, personal communication, March 13, 2013), it is also possible that injured employees with an unknown impairment rating were, on average, more severely injured than those with a known impairment rating. However, 58.1% of injured employees with a permanent impairment rating of 21% or more did RTW as of claim closure (relative to 26.6% of those with an unknown impairment rating). Therefore, even if injury severity is a contributing factor, it appears that workplace (e.g., attorney involvement) and potentially individual (e.g., recovery expectations) psychosocial characteristics are also influential components of the connection between knowledge of impairment rating and this study's RTW outcome.

It is also noteworthy that the first-order interaction between attorney involvement and severity of permanent impairment was included in the optimal RTW model. Interpretation of this interaction term reveals that severity of permanent impairment remains an important predictor of RTW status as of claim closure even when controlling for attorney involvement. Considering only injured employees who retained an attorney, *ceteris parabus*, those with a permanent impairment rating of 16% to 20% were 1.65 times more likely to fail to RTW as of claim closure than those with a permanent impairment rating of 1% to 5% (i.e., the reference group). Similarly, *ceteris parabus*, injured employees with a permanent impairment rating exceeding 20% were 1.57 times more likely to fail to RTW as of claim closure than the reference group among those with an attorney. While these findings give further credence to the existence of a positive relationship between impairment and disability, the lack of a known permanent impairment rating clearly remained the strongest predictor of RTW status as of claim closure for this variable. Specifically, *ceteris parabus*, those with an unknown permanent impairment rating were 3.60 times more likely to fail to RTW as of claim closure relative to the reference group among injured employees who retained attorneys. As previously suggested, this is likely a function of non-medical factors (e.g., a highly litigious claim and/or the presence of individual psychosocial characteristics) that often serve as obstacles to the RTW process.

Age.

The individual factor that had the most influence on the RTW status as of claim closure among this study's development dataset was age. Though the bivariate association between age and RTW status as of claim closure was *negligible* (φ_c = .018), an injured employee's age was found to be a significant contributor to the optimal RTW model. Concordant with previous rehabilitation research (e.g., Blackwell et al., 2003; Drake et al., 2000; Hackett et al., 2012; Pransky et al., 2006; Shaw et al., 2005), study results suggested that older injured employees were less likely to attain desirable RTW outcomes. In particular, *ceteris parabus*, injured employees aged 25 to 34 years (as of their date of injury or illness) were 27% more likely to fail to RTW as of claim closure than those aged 18 to 24 years. Relative to this same reference group, *ceteris parabus*, failure to RTW as of claim closure was 41% more likely to occur among injured employees aged 35 to 44 years, 77% more likely to occur among those aged 45 to 54 years and 148% more likely to occur among those aged 55 to 64 years.[61]

Some proposed reasons for the tendency for older workers to attain poorer RTW outcomes include an increased likelihood of preexisting conditions, an increased rate of co-morbidity, a slower recovery, and competing retirement options (Dasinger et al., 2000; Personick & Windau, 1995). This study included a proxy measure of the presence of pre-existing conditions (i.e., pre-existing claim status). Study results offer support for a *moderate* relationship (φ_c = .228) between age and the presence of preexisting conditions (as measured by pre-existing claim status). Study results also suggest that the first-order interaction between age and pre-existing claim status had some influence on the development dataset's RTW status as of

[61] While these percentages are based on the odds ratios obtained from the most parsimonious main effects only model, they are almost identical to those obtained in the optimal RTW model (i.e., when taking first-order interaction effects into account) as age was not included in any interaction term (see Tables 10 and 11).

claim closure (i.e., based on its inclusion in reduced main and first-order interaction effects models using less stringent *p*-values than .001). Another notable finding is that injured employees aged 55 to 64 years (46.0% were legally represented) were less likely to retain an attorney than injured employees under age 55 years (56.9% were legally represented). This may have been because older workers were likely to have established a more stable relationship with their pre-injury employer, as evidenced by their longer job tenure (with their pre-injury employer) relative to younger workers. For example, while the job tenure of nearly two-thirds (64.4%) of injured employees aged 55 to 64 years was more than five years, only about one-half (49.9%) of those aged 45 to 54 years and less than one-third (28.1%) of those under age 45 years had a job tenure of more than five years. Despite this presumed RTW facilitator (i.e., longer job tenure[62]), older workers were less likely to RTW as of claim closure than their younger counterparts following a work-related incident.

Pre-injury average weekly wage.

A second workplace factor included in the optimal RTW model (i.e., as part of a first-order interaction with pre-injury industry) as well as the most parsimonious main effects only model was pre-injury average weekly wage (AWW). In this study, the higher the average weekly wages of an injured Minnesota employee who had sustained permanent impairment and received VR services, the more likely he or she was to RTW as of claim closure. This was particularly true at the extremes as, *ceteris parabus*, injured employees with a pre-injury AWW of $500 or less were 1.94 times more likely to fail to RTW as of claim closure than those with a pre-injury AWW of more than $1,000 (i.e., taking into account main effects only). *Ceteris*

[62] It may be that at higher levels (e.g., more than 20 or 30 years) of job tenure becomes less of a RTW facilitator. For instance, an employer of an older injured employee may perceive the employee as being less capable of overcoming his or her injury (compared to a younger employee) sufficient to be productive enough to justify his or her remuneration (which would probably be relatively high given his or her tenure).

parabus, relative to injured employees with a pre-injury AWW of more than $1,000, those with a pre-injury AWW between $501 and $750 were 1.42 times more likely to fail to RTW by claim closure and those with a pre-injury AWW between $751 and $1,000 were 1.04 times more likely to fail to RTW by claim closure.

While the critically reviewed literature did not identify an injured employee's pre-injury wage level as a significant predictor of RTW outcomes, this finding does have a precedent. A historical cohort study that was conducted to assess various lumbar fusion outcomes in U.S. workers' compensation subjects likewise led to the finding that the odds of an injured employee returning to work were higher among those with higher weekly wages (Nguyen, Randolph, Talmage, Succop, & Travis, 2011). Nguyen et al. (2011), who acknowledged that "the association of wages and RTW status is seldom addressed in the medical literature" (p. 330), speculated that injured employees with higher weekly wages may be more motivated to RTW and/or may have greater labor market access (i.e., higher weekly wages may be a signal of more transferable job skills). In support of this supposition, this study's results reveal that injured employees with higher weekly wages were more likely to be married (e.g., 65.2% of injured employees with a pre-injury AWW of more than $1,000 were married) than those with lower weekly wages (e.g., 48.2% of injured employees with a pre-injury AWW of $500 or less were married). Thus, injured employees with higher weekly wages were presumably also likely to have more dependents (e.g., unemployed spouse and children) than those with lower weekly wages. In addition, injured employees with higher weekly wages tended to have higher levels of education relative to injured employees with lower-paying jobs. While nearly half (46.9%) of all injured employees with a pre-injury AWW of more than $1,000 had either completed a post-secondary vocational/technical program or received a bachelor's degree or more, fewer than one in 20 (4.9%) of those in this same wage category had a less than high school education. These findings are in accordance with Nguyen et al.'s (2011) inference that injured employees with higher incomes may have more incentive to RTW and/or more employment options from which to choose.[63]

Pre-injury industry.

Pre-injury industry was a third workplace factor included in the optimal RTW model (i.e., as a part of a first-order interaction with pre-injury AWW) and the most parsimonious main effect only model. The reference group for this predictor variable was the public administration sector which consists of establishments of federal, state, and local government agencies that are typically engaged in the organization and financing of the production of public goods and services (U.S. Department of Commerce, 2012a). Injured employees in this industry had a higher RTW rate (76.2%) than those in any other industry. However, while those in other industries had somewhat lower RTW rates, interpreting the difference in the odds of failure to RTW as of claim closure between those employed in public administration versus other industrial groups was difficult. This was because the 95% confidence intervals around the odds ratios associated with all industries included the value of 1.00. Consequently, with one potential exception, the comparisons between employment in various industries (e.g., leisure and hospitality; trade, transportation, and utilities; manufacturing) versus in public administration were not particularly useful predictors of the RTW status as of claim closure among development dataset members. Regarding the one possible exception, *ceteris parabus*, injured employees whose pre-injury industry was construction were 39% (i.e., odds ratio of 1.39 with a 95% confidence interval of 0.99 to 1.95) more likely to fail to RTW by claim closure than those

[63] This is based on the reasonable assumption that those with a higher level of education generally have more employment opportunities.

whose pre-injury industry was public administration. As employment is typically (but not always) more arduous in construction than in public administration, this finding appears to be consistent with previous studies whose results indicated that injured employees or military personnel with low back pain were less likely to attain positive work outcomes if employed in a physically demanding job (e.g., Butterfield et al., 1998; Feuerstein et al., 2001; Shaw et al., 2005).

As previously mentioned, the first-order interaction between pre-injury AWW and pre-injury industry was retained in the optimal RTW model. Given the non-hierarchical structure of the optimal RTW model, interpretation of this interaction term was complicated. To help with this interpretation, a hierarchical logistic regression analysis was performed that included *all* individual components (including pre-injury AWW and pre-injury industry[64]) of the interactions included in the optimal RTW model. While it was apparent that pre-injury AWW had a stronger influence on RTW status as of claim closure than pre-injury industry (e.g., as evidenced by the results of bivariate analysis and with a comparison of the Wald χ^2 statistics for these predictors in the most parsimonious main effects only model), interpretation of this interaction term also revealed that the effect of pre-injury AWW on this study's RTW outcome was dependent on the industry in which an injured employee previously worked. For example, *ceteris parabus*, for injured employees in manufacturing, the main effect of pre-injury AWW on RTW status as of claim closure held true as the odds of failure to RTW by claim closure were 100% higher for those with weekly wages of $500 or less, 60% higher for those with weekly wages of $501 to $750 and 2% higher for those with weekly wages of $751 to $1,000 relative to those earning

[64] To make the analysis hierarchical, the only two additions to the optimal RTW model were pre-injury AWW and pre-injury industry as attorney involvement, severity of permanent impairment, age, and job tenure were already included in the model.

more than $1,000. Meanwhile, *ceteris parabus*, for injured employees in construction, the odds of failure to RTW by claim closure were 99% higher for those with earning $500 or less (i.e., per week), 31% higher for those earning $501 to $750, and 28% lower for those earning $751 to $1,000 relative to those earning more than $1,000. As suggested by these two examples, with the exception of the financial activities industry, injured employees with weekly wages of $500 or less and $501 to $750 were consistently somewhat more likely to fail to RTW as of claim closure than their counterparts with weekly wages exceeding $1,000 (with the odds of failure to RTW by claim closure relative to the reference group being higher for those earning $500 or less than for those earning $501 to 750 across *all* industries).[65] However, the main effect of pre-injury AWW on RTW status as of claim closure became more convoluted when comparing injured employees with weekly wages of $751 to $1,000 and those with weekly wages of more than $1,000 across industries. This was because in four industries (i.e., other services; financial activities; construction; professional and business services) the odds of failure to RTW by claim closure were actually *higher* for those earning more than $1,000 per week than for those earning $751 to $1,000 per week. One possible reason for this occurrence is that high wage earners in these industries (e.g., superintendents in the construction industry) who are unable to return to their customary employment may have greater difficulty finding alternative employment that would offer them comparable remuneration. Irrespective of the reasoning behind this finding, it is clear that an injured employee's pre-injury industry is an important determinant of the association between his or her pre-injury AWW and RTW status as of claim closure.

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[65] In the financial activities industry, injured employees with weekly wages of $1,000 or less (including those with weekly wages of $500 or less, $501 to $750, and $751 to $1,000) are actually somewhat less likely to fail to RTW by claim closure than those with weekly wages of more than $1,000.

Job tenure.

An injured employee's job tenure was the fourth workplace factor that was included in this study's optimal RTW model (i.e., as a main effect and as part of a first-order interaction effect with attorney involvement) and in the most parsimonious main effects only model. Among the development dataset, injured employees with shorter job tenure with their pre-injury employer were more likely to fail to RTW as of claim closure. In particular, *ceteris parabus*, injured employees with less than one year of tenure were 1.49 times more likely to fail to RTW by claim closure and those with one to five years of tenure were 1.09 times more likely to fail to RTW by claim closure relative to those with more than five years of tenure. Similar findings regarding the relationship between job tenure and employment outcomes have been reported by Feuerstein et al. (2001), Pransky et al. (2006), and Shaw et al. (2005). As job satisfaction is an antecedent to job tenure (i.e., the ultimate criterion of work adjustment) according to the Minnesota Theory of Work Adjustment, it may be that injured employees with longer job tenure have a stronger attachment to (and/or enjoyment of) the workplace. In addition to the assumed enhanced RTW motivation due to their labor market attachment, injured employees with longer job tenure may also have more incentive to RTW given that they tend to have higher weekly wages. For example, in this study, 61.2% (2,581 out of 4,220) of the injured employees with a pre-injury AWW in excess of $1,000 had also been employed with their pre-injury employer for more than five years. Beyond these presumed RTW inducements, injured employees with longer job tenure were also less likely to retain an attorney. As previously noted, 67.0% of injured employees with less than one year tenure were legally represented, 60.4% of those with one to five years of tenure were legally represented, and only 43.1% of those with more than five years of tenure were legally represented. Therefore, it appears that injured employees with longer job tenure are more likely to have higher levels of job satisfaction, to feel secure in their relationship with their employer and, ultimately, to RTW as of claim closure.

The relationship between job tenure and RTW status as of claim closure proved to be tempered by the presence of attorney involvement. This became evident when assessing the influence of the first-order interaction between attorney involvement and job tenure on this study's RTW outcome. When only considering claims within the development dataset in which an attorney was involved, *ceteris parabus*, injured employees with less than one year of tenure were just 1.19 times more likely to fail to RTW by claim closure than those with more than five years of tenure. Further, *ceteris parabus*, injured employees with one to five years of tenure were actually 0.99 times more likely (i.e., 1% less likely) to fail to RTW by claim closure than those with more than five years of tenure. Though this reveals that there remains a relevant discrepancy in the outcome between those with less than one year and more than five years of tenure, it also confirms that this discrepancy is much less pronounced when isolating injured employees who retained an attorney (i.e., relative to the study's accessible population irrespective of attorney involvement). Furthermore, it suggests that the job tenure levels of one to five years and more than five years could be collapsed as there is virtually no difference in the risk for failure to RTW among injured employees with more than one year of job tenure after controlling for attorney involvement. This revelation offers additional support for the finding that attorney involvement is the preeminent predictor of RTW status as of claim closure among this study's development dataset (and likely its validation dataset) of claims of injured employees who sustained permanent impairment and received VR services.

Part of body affected.

Though not included in the optimal RTW model (or in the most parsimonious main effects only model), part of body affected did have a bivariate relationship with RTW status as of claim closure that is worthy of discussion. Study results showed that RTW rates among injured employee claims in the development dataset were lowest when work-related injuries were to the head and neck, including throat (53.1%) or to the back, including the spine and spinal cord (55.5%). The RTW rate (59.1%) related to claims of injured employees who sustained injuries to multiple body parts was also somewhat lower than the RTW rate (62.3%) for this study's accessible population. Conversely, RTW rates were highest when claims were in regards to injuries to lower extremities (70.3%) or to the trunk and body systems (67.5%) and were near the accessible population's average when claims involved injuries to the upper extremities (61.3%). In light of these findings, it is interesting that so many studies (e.g., Butterfield, et al., 1998; Dawson et al., 2004; Dionne et al., 2005; Hansson et al., 2006; Hess et al., 2000; Heymans et al., 2009; Kreutzer et al., 2003; Pransky et al., 2006; Schultz et al., 2002; Shaw et al., 2005) related to the prediction of RTW outcomes involve populations of individuals with injuries to the head and neck (e.g., traumatic brain injury) and/or to the back (e.g., lumbar spine injury). While low back conditions are a focus of rehabilitation (and medical) research in part due to their common occurrence, another reason for the interest in injuries to the head and neck as well as to the back could be due to the high variability in functional outcomes associated with injuries to these body parts. Extending this proposition, it may be that this uncertainty in functional outcome tends to increase an injured employee's reservations about his or her ability to return to the work force. Though this proposed explanation regarding the relationship between part of body affected and RTW status as of claim closure requires further investigation, it appears consistent with the finding that an attorney was involved in more than two-thirds (67.2%) of claims filed by employees with injuries to the head and neck or to the back but fewer than one-half (49.5%) of claims filed by employees with injuries to other body parts (e.g., upper or lower extremities).

Education.

Another predictor that was not retained in the optimal RTW model (or the most parsimonious main effects only model) that had a notable bivariate relationship with RTW status as of claim closure is the individual factor of education. Similar to the results reported by Hess et al. (2000), Krause et al. (1998), Murphy et al. (2003), Truchon et al. (2012), and Walker et al. (2006), attainment of less education proved to be associated with higher risk for failure to RTW as of claim closure. Of particular relevance was the poor RTW rate of injured employees with a less than high school education. While nearly two-thirds (64.1%) of injured employees with at least a high school education (including a general equivalency diploma) did RTW by claim closure, fewer than one-half (47.4%) of those without a high school education accomplished this goal.[66] One possible reason that less-educated injured employees (particularly those without a high school education) are more likely to achieve undesirable RTW outcomes is that they typically have limited access (relative to those with higher levels of education) to less arduous occupations. Therefore, if a less-educated injured employee is unable to return to his or her (often physically demanding) pre-injury occupation, alternative employment opportunities will probably be scarce if the injured employee is unable to further his or her education (e.g., due to borderline to below average intellectual functioning). Another plausible explanation for the poor RTW rates of injured employees with a less than high school education is the relatively low

[66] The only level of a predictor variable included in this study with a lower RTW rate than "less than high school education" (47.4%) was "attorney involved" (41.8%). In fact, these were the only two characteristics of claims (or injured employees filing claims) in which the RTW rate was below 50%.

remuneration such workers typically receive. Only about three out of 10 (29.8%) injured employees with a less than high school education, and whose claims were included in this study, had a pre-injury AWW of more than $750 while roughly one-third (33.6%) had a pre-injury AWW of $500 or less. Conversely, among those with a high school education or more, over one-half (52.8%) had a pre-injury AWW of more than $750 while only about one-fifth (19.6%) had a pre-injury AWW of $500 or less. Thus, it appears that, on average, injured employees without a high school education have less opportunity *and* less incentive to RTW than those with a high school education or more.[67]

Implications for Action

The practical implications emanating from this study's findings directly relate to their potential contribution to improving the current VR benefit eligibility determination process in Minnesota's workers' compensation system. Through this research endeavor, a *mechanical prediction* method (i.e., the optimal RTW model) was both developed and internally validated and proven to be both precise and accurate in its ability to predict the RTW status as of claim closure of injured Minnesota employees who sustained permanent impairment and received VR services. This study's optimal RTW model appears to be a valuable tool that can serve as a supplement to, if not a substitute for, the *clinical judgment* method that is presently used to determine which injured Minnesota employees possess RTW potential and the corresponding capacity to benefit from receipt of VR services.

The integration of the optimal RTW model into the VR benefit eligibility determination process has several advantages. Perhaps the most important is that it could significantly reduce

[67] The lack of incentive is particularly true for injured employees who receive (or have the potential to receive) health insurance benefits as part of their disability compensation but who would not receive health insurance benefits in any of their residual employment opportunities.

the subjectivity that is inherently associated with reliance on clinical judgment to determine which injured employees are *qualified employees*.[68] As recognized by Grubbs, Cassell, and Mulkey (2006), decisions made by rehabilitation counselors are often influenced by "values or hunches … even when there is a lack of data to support the chosen course of action" (p. 134). Given that disability is such a complex construct with many determinants, it is of little wonder that applying a subjective decision-making approach to the evaluation of rehabilitation potential can lead to undesirable outcomes similar to those experienced in Minnesota's workers' compensation system in recent years (i.e., increased VR services costs and decreased RTW rates in conjunction with increased VR participation rates). The only solution to the uncertainty surrounding the reliability of the current VR benefit selection process is for decision-makers to have better knowledge as to the probable outcome of an injured employee's receipt of VR services prior to service delivery. Fortunately, access to this study's optimal RTW model, which was derived from the population of interest and which specifies the relative importance of key disability risk factors, would do just that.

In addition to improving the consistency in the qualified employee selection process, use of this study's optimal RTW model would likely improve the accuracy of VR eligibility determinations. With the ability to accurately distinguish between injured employees who would and who would not RTW as of claim closure with receipt of VR services approximately three-fourths of the time, qualified rehabilitation consultants should be able to make more accurate decisions about the RTW (and thus rehabilitation) potential of injured employees who have sustained permanent impairment. This is particularly important given that a basic rehabilitation counselor competency (for those working within Minnesota's workers' compensation system and

[68] Strictly speaking, sole reliance on the optimal RTW model would completely eliminate subjectivity, and any resulting inconsistency, in the eligibility determination process.

elsewhere) is the ability to diagnose employment (including RTW) potential (Sink, Porter, Rubin, & Painter, 1979). Though the ability to prognosticate is a skill expected of rehabilitation professionals, it has proven to be a difficult skill to master. Accordingly, a mechanical prediction method that has been demonstrated to be a reliable and valid forecaster of the RTW outcomes of injured Minnesota employees would appear to be a useful addition to the rehabilitation selection process.

Given the enhanced predictive capacity that would accompany the use of this study's optimal RTW model, injured employees could be classified according to the degree of rehabilitation potential they possess. For example, prior to receipt of VR services, injured employees could be identified as having *low* (i.e., probability of failure to RTW as of claim closure is greater than two-thirds), *moderate* (i.e., probability of failure to RTW as of claim closure is between one-third and two-thirds), or *high* (i.e., probability of failure to RTW as of claim closure is less than one-third) rehabilitation potential. A qualified rehabilitation consultant (or other decision maker) would thus know that even with receipt of VR services an injured employee with low rehabilitation potential would likely successfully RTW as of claim closure only about 25.0% (819 out of 3,274) of the time. A qualified rehabilitation consultant would also know that an injured employee with moderate rehabilitation potential would likely successfully RTW by claim closure about 50.4% of the time (2,378 out of 4,716) and that an injured employee with high rehabilitation potential would likely successfully RTW by claim closure about 86.4% (6,377 out of 7,382) of the time (with receipt of VR services). As was suggested by Hester, Decelles, and Gaddis (1986), VR resources are most efficiently used when they are *not* disproportionately allocated to those who would RTW without assistance and to those who would not RTW even with assistance.[69] Based on this guidance, injured employees with moderate rehabilitation potential are likely those who are most in need of *and* capable of benefitting from VR services. In fact, in most cases, those with moderate rehabilitation potential could probably be provided VR services (if such services are requested) without the need for a formal rehabilitation consultation. This would in turn allow for more careful scrutiny to be placed on determining the feasibility of providing VR benefits to those with low and high rehabilitation potential.[70]

It is noteworthy that the identification of injured employees as having either low or high rehabilitation potential is not justification for denial of VR benefits. Rather, as previously noted, it is these claims that would typically require careful scrutiny during the selection process as well as close monitoring should VR services be provided. While the use of the optimal RTW model would almost assuredly aid the assessment of rehabilitation potential, it appears that qualified rehabilitation consultants are generally offering VR services to those who stand to benefit from them the most. This is evidenced by the fact that the median VR service cost was highest for injured employees with moderate rehabilitation potential (i.e., $10,773 for those with moderate rehabilitation potential, $8,225 for those with low rehabilitation potential, and $3,967 for those with high employment potential).[71] Nevertheless, it is also apparent that VR benefits are being disproportionately allocated to injured employees who are not returning to work. For example, the mean VR service cost ($12,448) for those who did not RTW by claim closure was 56.1%

[69] This could be either due to an inability or an unwillingness to RTW with receipt of VR services.

[70] This scrutiny should extend beyond the determination of *if* VR benefits should be provided to address the issues of *how much* and *what type* of services should be provided to an injured employee with either low or high rehabilitation potential. Such decisions would likely require consideration of case-specific information by a qualified rehabilitation consultant.

[71] This is also the case for the mean VR service cost which was $14,163 for those with moderate rehabilitation potential, $10,912 for those with low rehabilitation potential, and $6,230 for those with high rehabilitation potential.

greater than the mean VR service cost ($7,973) for those who did RTW by claim closure. In addition, of the injured employees who received at least $20,000 worth of VR benefits and whose claims were part of this study's accessible population, fewer than one-half (43.8%) of them were able to RTW as of claim closure.[72] Ultimately, it still may be appropriate to provide VR benefits to many injured employees with limited RTW prospects due to rehabilitation professional ethical standards (e.g., false positive errors are preferable to false negative errors in this instance). However, with the ability to identify such claims during the rehabilitation selection process, careful consideration can be given to the decision of whether VR benefits are a viable option for a particular claim. Also, if VR benefits are provided, such claims can be closely monitored in attempt to minimize the risk of them becoming undesirable outliers in which injured employees with limited RTW prospects (i.e., a predicted probability of successful RTW as of claim closure of less than 50%) receive a disproportionately high amount of VR services only to fail to RTW by claim closure.

In addition to its ability to assist with VR benefit eligibility determination in Minnesota's workers' compensation system, this study's optimal RTW model could be used when evaluating the performance of qualified rehabilitation consultants (i.e., beyond their ability to identify the rehabilitation potential of injured employees). An auxiliary benefit of using the optimal RTW model to identify the rehabilitation potential of injured Minnesota employees is that the same information can help to objectively assess the difficulty of a qualified rehabilitation consultant's caseload. This knowledge would therefore allow for the complexity (relative to other consultants) of a qualified rehabilitation consultant's injured employee caseload to be included as

[72] The mean cost of VR services for an injured employee claim included in this study was $9,660.92. Therefore, injured employees whose VR services cost $20,000 or more received more than double what was spent on the average claim.

part of his or her performance evaluation. Moreover, the pay scale for qualified rehabilitation consultants could be restructured to take into account a claim's difficulty with respect to helping an injured employee RTW as of claim closure. Offering an incentive (e.g., a bonus payment for achieving successful RTW as of claim closure) to qualified rehabilitation consultants working with injured employees with low rehabilitation potential (or for those with a predicted probability of failure to RTW as of claim closure of more than 50%) would ideally improve the RTW rates of injured employees most vulnerable to long-term, if not permanent, work disability (see following paragraph). It would also award qualified rehabilitation consultants for quality work on particularly complex claims.

Regardless of whether or not the optimal RTW model is directly used within Minnesota's workers' compensation system, study results are useful to workers' compensation policy makers (e.g., Minnesota state legislators) in that they identify vulnerable populations of injured employees who have lower RTW rates than the general population of injured Minnesota employees despite receipt of VR services. In particular, study results clearly indicate that injured employees (especially injured female employees[73]) with a less than high school education have a difficult time making a successful work adjustment after sustaining work-related permanent impairment. The challenges that an injured employee with a less than high school education faces are likely compounded by the fact that such workers are more likely to be employed in low-wage, dead-end jobs with high turnover relative to those with a high school education or

[73] While 49.6% (567 out of 1,143) of males with a less than high school education were able to successfully RTW as of claim closure, only 42.4% (209 out of 493) of females with a less than high school education accomplished this goal.

more.[74] Thus, injured employees with a less than high school education are also more likely to possess two additional factors that are associated with failure to RTW as of claim closure: 1) a pre-injury AWW of $500 or less; and 2) less than one year of job tenure (with their pre-injury employer). The fact that, even with receipt of VR services, injured employees who sustain permanent impairment fail to RTW by claim closure more often than they succeed in this endeavor underscores the value of education. This fact also serves as a strong reminder to policy makers that the continual improvement of the education and training not only of tomorrow's, but also today's, workforce must remain a top priority. With respect to today's workforce (including injured employees), it appears that this priority should emphasize helping those with a limited education not merely to improve their basic academic skills but to actually achieve high school equivalency (GED or adult high school diploma) and attain the skills necessary to enter post-secondary education and training programs.[75] As evidenced by this study's results, the failure of injured employees without a diploma to achieve these higher levels of education all too often results in the undesirable outcome of failure to RTW as of claim closure.

Another important implication from this study's results is that avoidance of unnecessary attorney involvement (i.e. attorney involvement in claims in which statutory benefits would have likely been received by the injured employee even without legal representation) may be of

[74] Regarding injured employees with a less than high school education, 33.6% (549 out of 1,636) had a pre-injury AWW of $500 or less and 30.6% (500 out of 1,636) had less than one year of job tenure. Regarding injured employees with a high school education or more, 19.6% (2,699 out of 13,736) had a pre-injury AWW of $500 or less and 24.4% (3,355 out of 13,736) had less than one year of job tenure.

[75] Some injured employees with a limited education may not possess the intellectual functioning to obtain a high school equivalency diploma. However, this should only be the case for those whose intelligence is no higher than the lower levels of the below average range of intellectual functioning (i.e., those with an intellectual quotient no higher than 80 to 85). Likewise, some injured employees with a limited education may have difficulty obtaining higher levels of education due to a learning disability which adversely affects their achievement levels. A qualified rehabilitation consultant would likely have to determine whether an injured employee with a learning disability was capable of attaining additional education on a case-by-case basis.

benefit to all disability stakeholders involved in a workers' compensation claim.[76] As previously noted, the decision of whether or not to retain an attorney for injured Minnesota employees who sustained permanent impairment and received VR services seems to be associated with the uncertainty (or even doubt) that exists regarding their ability to return to suitable gainful employment. Injured employees with greater uncertainty (or doubt) may be more likely to retain an attorney due to having high perceptions of the severity of their disability and/or low recovery (including RTW) expectations. In some instances, the primary reasons for an injured employee having these beliefs may be due to factors that are difficult, if not impossible, to change (e.g., higher degree of permanent impairment). However, in many (if not most) instances, there are secondary prevention approaches (i.e., methods designed to prevent the progression of an acute condition to chronic disability) that can be taken by various disability stakeholders that may be beneficial to reducing an injured employee's insecurity about returning to the workforce (Sullivan et al., 2005). For example, employers can create a more trusting environment with their employees by adopting proactive disability management strategies such as encouraging early reporting of injuries, developing modified duty programs, and maintaining open communication among all participants in the RTW process (Shaw et al., 2005).[77] Insurers can ensure that indemnity payments are promptly disbursed and that case managers are well trained in keeping injured employees informed of their treatment options (Johnson, 2012). Health care providers can offer *timely* medical reassurance to injured employees in an effort to educate them about their health condition and residual symptoms, to reduce their fear-avoidance beliefs, and to

[76] This definition of unnecessary attorney involvement was offered by Dr. Bogdan Savych, a public policy analyst with the WCRI (Johnson, 2012).

[77] This encouragement should be accompanied by a discussion of *how* an employee should report an injury and should begin as early as possible (e.g., date of hire) in order to foster a culture of open communication.

promote the benefits of the resumption (or initiation) of an active lifestyle (Sullivan et al., 2005).[78] Additionally, qualified rehabilitation consultants can help to lower an injured employee's perception of the severity of his or her disability (and to raise his or her RTW expectations) by identifying reasonable accommodations that can be made within the workplace and, if necessary, by assisting an injured employee in acquiring relevant job skills that can facilitate his or her return to alternative employment. Taking such actions to reduce an injured employee's uncertainties (and fears) about the RTW process is likely to curtail unnecessary attorney involvement and, accordingly, to increase the RTW prospects of those who have sustained permanent impairment and received VR services (and potentially others as well).

Recommendations for Further Research

Guidance for future research related to the prediction of RTW outcomes is offered by the limitations of this study. Though the ability to conduct an experimental study is unlikely given ethical concerns about withholding the provision of VR services to injured employees who may RTW with receipt of such benefits, future studies could be structured so that they are prospective rather than retrospective in nature. Conducting a prospective study would allow for the collection of data on predictor variables not included in this study but which prior research suggests may influence an individual's RTW outcome. Examples of such variables include, but are not limited to, a host of psychological (e.g., levels of depression, anxiety, somatization, and pain catastrophizing) and psychosocial (e.g., an injured employee's perception of the severity of his or her disability, RTW expectations, fear-avoidance beliefs, and health locus of control)

[78] Researchers have suggested that medical reassurance may be more effective in the early stages (e.g., acute stage) of work disability (Sullivan et al., 2005).

characteristics.[79] A prospective study would also allow for the collection of information on other, more objective, variables such as an injured employee's race or ethnicity and general learning ability as well as the physical demands and skill level of his or her pre-injury employment.[80] Additionally, the impact of process variables such as type of VR services rendered on an injured employee's RTW outcome could be evaluated.

Regardless of whether a study is prospective or retrospective, it would generally be preferable that data be collected at the highest measurement level possible. One limitation of this study was that this researcher's data access was dependent on the agreement that all data made available would be presented in a discrete rather than continuous manner. This necessarily resulted in some degree of information loss and likely some reduction in statistical power. This study weakness could be avoided in future research if access to ratio- or interval-level data could be obtained for certain variables (e.g., severity of permanent impairment). A related limitation of this study was the use of a binary measure of an injured employee's RTW status at a single point in time (i.e., as of claim closure). In order to better account for the dynamic nature of the RTW process, which can involve multiple labor market entries and exits, a less static outcome could be used. One option, particularly if conducting a prospective study, would be to assess an injured employee's RTW status at multiple points in time (e.g., 6 months, 1 year, and 3 years after the date of injury). Other options include measuring an injured employee's duration of disability

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[79] This would allow for a more pure biopsychosocial perspective to be taken in the model development process by extending beyond the sole reliance on objective measures such as attorney involvement and job tenure that may indirectly account for some of the influence of an injured employee's psychological and/or psychosocial characteristics on his or her RTW outcome.

[80] Objective measures of an injured employee's general learning ability and an occupation's physical demands and skill level include the following: a standardized intelligence test to measure an injured employee's general learning ability; the U.S. Department of Labor's strength scale to measure the physical demands of an injured employee's pre-injury occupation; the U.S. Department of Labor's specific vocational preparation scale to measure the skill level of an injured employee's pre-injury occupation.

(e.g., time loss days in a workers' compensation setting) and making a distinction between an injured employee's first RTW (e.g., time from an injured employee's date of injury to his or her first day of RTW) and lasting RTW (e.g., time from an injured employee's date of injury to the date he or she sustains RTW for three months). Still another option would be to include a combination of these RTW outcome measures to more precisely determine the impact of an employee's injury on his or her residual labor market experience.

While the internal validity of this study's optimal RTW model was established, the model's external validity was not. That is, this study did not assess the optimal RTW model's generalizability to populations that are "plausibly related" but yet fully independent from this study's accessible population (e.g., injured employees who have sustained permanent impairment and received VR services in other state workers' compensation systems) (Justice, Covinsky, & Berlin, 1999). Future research that applied this study's modeling process to data collected from samples of injured employees from one or more other U.S. workers' compensation systems (i.e., other than Minnesota's) could therefore investigate whether this study's findings are applicable to a broader population.

Given the results of this study, future research should aim to gain a greater understanding of the relationship between attorney involvement and RTW outcomes. Of particular interest would be to identify the reasons why injured employees make the decision to retain an attorney. While this study offered some potential explanations for the reasoning behind this important decision (e.g., injured employees with greater uncertainty or fear about the RTW process are more likely to seek legal assistance), these were merely inferences based on the associations of study variables in combination with a critical review of the literature. Future studies that assess the correlation between psychological and/or psychosocial variables and attorney involvement would be helpful in determining the efficacy of early interventions (e.g., medical reassurance) aimed at reducing risk factors (e.g., low recovery expectations; high fear-avoidance beliefs) for prolonged work disability. Another topic worthy of further investigation would be whether attorney involvement is more accurately classified as a personal (e.g., individual) or environmental (e.g., workplace) factor within the context of the WHO's ICF model (or whether it represents a fusion of contextual factors). Though this researcher assumed that attorney involvement was representative of the relationship between an injured employee and his or her pre-injury employer (and thus a workplace factor) for purposes of this study, future research may offer additional insight into the validity of this assumption. One other possibility would be to expand the information that is collected with respect to attorney involvement in attempt to account for factors such as the time elapsed between the date of incident and the date an injured employee retains an attorney (Butterfield et al., 1998) or the extent to which an attorney is supportive of the RTW process (Pransky et al., 2006). Ultimately, whichever approach is taken, any study able to add clarity to the relationship between attorney involvement and RTW outcomes would be a significant contribution to rehabilitation research.

Concluding Remarks

The primary result of this study is the development and (internal) validation of a RTW model that is able to precisely and accurately predict the RTW status as of claim closure of injured employees who sustained permanent impairment and received VR services in Minnesota's workers' compensation system. The performance of this study's optimal RTW model when applied to the accessible population suggests that it is likely a useful tool for assessing the rehabilitation potential of injured Minnesota employees and thus may serve as a supplement to, if not a substitute for, the current clinical judgment method that is relied on to determine VR benefit eligibility. In addition to its prospective value in eligibility determination, this study's optimal RTW model can also be used to objectively assess the difficulty of a qualified rehabilitation consultant's caseload. Accordingly, the predictive model may be of value when included as part of the performance evaluation of qualified rehabilitation consultants and may allow for the restructuring of consultants' pay scale in order to offer an incentive to those working with injured employees with relatively poor RTW prospects.

Even if the optimal RTW model is not directly used within Minnesota's workers' compensation system, this study's findings offer valuable insight into the factors that influence an injured employee's RTW outcome. Perhaps most importantly, results of this research are consistent with existing studies that have found [work] disability to be a multifactorial, biopsychosocial construct. Results of this study specifically suggest that the RTW status as of claim closure of injured Minnesota employees who sustained a permanent impairment and received VR services is a function of the main and first-order interaction effects of medical (severity of permanent impairment), individual (age), *and* workplace (job tenure; pre-injury AWW; attorney involvement; pre-injury industry) factors. Regarding these six factors, injured employees who are more likely to fail to RTW as of claim closure (and who thus have lower rehabilitation potential) are those who share the following characteristics: higher levels of permanent impairment; older age; shorter job tenure; lower pre-injury AWW; legally represented; pre-injury employment in the construction industry. Bivariate analysis also shows that those with injuries to their head and neck or to their back as well as those with a less than high school education are at greater risk for failure to RTW as of claim closure. As evidenced by these characteristics, study results reveal that injured employees with greater uncertainty, and thus greater doubt, about their RTW prospects are more likely to retain an attorney and less likely to RTW as of claim closure. In particular, study results indicate that injured employees (principally injured female employees) with a less than high school education are an especially vulnerable population in terms of achieving undesirable RTW outcomes despite receipt of VR services.

This researcher is hopeful that this study's results will prove useful to the Minnesota DLI by offering an objective, evidence-based method of evaluating (prior to the receipt of VR services) the rehabilitation potential of injured employees who have sustained permanent impairment. He is also hopeful that this research will offer helpful guidance to rehabilitation professionals (both in Minnesota and elsewhere) who devote their time and efforts to the noble cause of assisting injured employees in returning to suitable gainful employment. Finally, this researcher is optimistic that this study will lay a foundation for future research on predicting RTW outcomes and foster greater interest among researchers, educators, *and* practitioners alike in searching for methods to improve this fundamental rehabilitation counselor competency.

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Appendix A

Definition of Key Terms

The following definitions are provided to assist the reader in understanding several key terms used in this study:

Disability - An inability to perform or limitation in performing socially defined roles and tasks expected of an individual within a sociocultural and physical environment. These roles and tasks are organized in spheres of life activities such as those of the family or other interpersonal relations (e.g., work, education, recreation, self-care) (Nagi, 1991, p. 315).

Functional limitation - An attribute that refers to the person and is described as a restriction in performance at the whole person level (Jette, 2006, p. 728). Functional limitations are the most direct way through which impairments contribute to disability (Nagi, 1991, p. 314-315).

Impairment - A significant deviation, loss or loss of use of any body structure or body function in an individual with a health condition, disorder or disease (Rondinelli et al., 2008, p. 5). Impairments are of an anatomical, physiological, mental or emotional nature and occur at the organ or body system level (Nagi, 1991, p. 314).

Injured employee - An employee who has sustained an injury or contracted an illness on the job and who has successfully filed a workers' compensation claim with Minnesota's Department of Labor and Industry.

Maximum medical improvement - The date after which no further significant recovery from or significant lasting improvement to a personal injury can reasonably be anticipated, based upon reasonable medical probability, irrespective and regardless of subjective complaints of pain (Minnesota Statutes 2011, section 176.011, subdivision 13a).

Pathology - A biochemical or physiological abnormality that is detected and medically labeled as a disease, injury or congenital/developmental condition (Verbrugge & Jette, 1994, p. 3).

Pathology may be acute or chronic in nature and, when meeting certain criteria, is expressed as a diagnosis.

Permanent and partial disability - A disability claim type in Minnesota's workers' compensation system in which an injured employee has been determined to have sustained permanent functional impairment resulting from a work-related injury or illness (Berry & Zaidman, 2013, p. 13). Though an injured employee possesses permanent functional impairment from a work-related injury or illness, he or she does not meet the other requirements of having a permanent and total disability.

Permanent and total disability - A disability claim type in Minnesota's workers' compensation system in which an injured employee has been determined to have sustained one of the severe work-related injuries specified in law or who, because of a work-related injury or illness in combination with other factors (e.g., age, education, training, experience), is permanently unable to secure gainful employment (Berry & Zaidman, 2013, p. 13). The following are the severe work-related injuries that are specified in law:

1. the total and permanent loss of the sight of both eyes, the loss of both arms at the shoulder, the loss of both legs so close to the hips that no effective artificial members can be used, complete and permanent paralysis, total and permanent loss of mental faculties; or

2. any other injury which totally and permanently incapacitates the employee from working at an occupation which brings the employee an income, provided that the employee must also meet the criteria of one of the following items:

> a) the employee has at least a 17 percent permanent partial disability rating of the whole body; b) the employee has a permanent partial disability rating of the whole body of at least 15 percent and the employee is at least 50 years old at the time of injury; or c) the

employee has a permanent partial disability rating of the whole body of at least 13 percent and the employee is at least 55 years old at the time of injury, and has not completed grade 12 or obtained a general educational development (GED) certificate (Minnesota Statutes 2011, section 176.101, subdivision 5).

Pre-injury average weekly wage - The weekly wages that an injured employee was receiving at the time of his or her work-related injury or illness. An injured employee's weekly wage is arrived at by multiplying his or her daily wage by the number of days and fractional days normally worked in the business of the employer for the employment involved (Minnesota Statutes 2011, section 176.011, subdivision 18).

Qualified employee - An employee who, because of the effects of a work-related injury or disease, whether or not combined with the effects of a prior injury or disability: a) is permanently precluded or is likely to be permanently precluded from engaging in the employee's usual and customary occupation or from engaging in the job the employee held at the time of injury; b) cannot reasonably be expected to return to suitable gainful employment with the date-of-injury employer; and c) can reasonably be expected to return to suitable gainful employment through the provision of rehabilitation services, considering the treating physician's opinion of the employee's work ability (Minnesota Rules 2011, part 5220.0100, subpart 22).

Qualified rehabilitation consultant - A person who is professionally trained and experienced and who is registered by the Minnesota Department of Labor and Industry commissioner to provide a rehabilitation consultation and to develop and implement an appropriate plan of rehabilitation services for an employee entitled to rehabilitation benefits (Minnesota Rules 2011, part 5220.0100, subpart 23).

Rehabilitation consultation - A meeting of the employee and assigned qualified rehabilitation consultant to determine whether the employee is a qualified employee, considering the treating physician's opinion of the employee's work ability (Minnesota Rules 2011, part 5220.0100, subpart 26).

Rehabilitation plan - A written document completed by the assigned qualified rehabilitation consultant … describing a vocational goal and the specific services by which the qualified employee will be returned to suitable gainful employment (Minnesota Rules 2011, part 5220.0100, subpart 27).

Rehabilitation services - A program of vocational rehabilitation, including medical management, designed to restore the injured employee so the employee may return to a job related to the employee's former employment or to a job in another work area which produces an economic status as close as possible to that the employee would have enjoyed without disability. The program begins with the first in-person visit of the employee by the assigned qualified rehabilitation consultant, including a visit for purposes of a rehabilitation consultation. The program consists of the sequential delivery and coordination or services by rehabilitation providers under an individualized rehabilitation plan. Specific services under this program may include, but are not limited to, vocational evaluation, counseling, job analysis, job modification, job development, job placement, labor market survey, vocational testing, transferable skills analysis, work adjustment, job-seeking skills training, on-the-job training, and retraining (Minnesota Rules 2011, part 5220.0100, subpart 29; Minnesota Statues 2011, section 176.102, subdivision 1, paragraph (b)).

Return to work (RTW) potential - An injured employee's potential to return to suitable gainful employment with the assistance of VR benefits. An injured employee with RTW potential must possess some degree of employability (refers to supply-side factors such as an individual's skills, abilities, credentials, and qualifications) *and* placeability (refers to demand-side factors such as an individual's actual ability to meet employer hiring standards in a given geographical area) on the open labor market (Nagi, 1965, p. 110-111; Power, 2006, p. 16-22).

Suitable gainful employment - Employment which is reasonably attainable and which offers an opportunity to restore the injured employee as soon as possible and as nearly as possible to employment which produces an economic status as close as possible to that which the employee would have enjoyed without disability. Consideration shall be given to the employee's former employment and the employee's qualifications, including but not limited to the employee's age, education, previous work history, interests, and skills (Minnesota Rules 2011, part 5220.0100, subpart 34).

Temporary and partial disability - A disability claim type in Minnesota's workers' compensation system in which an injured employee has returned to work and is temporarily earning less than his or her pre-injury wages because of his or her work-related injury or illness (e.g., temporarily unable to work on full-time basis or unable to perform full duties of job) (Berry & Zaidman, 2013, p. 12).

Temporary and total disability - A disability claim type in Minnesota's workers' compensation system which an injured employee is temporarily unable to work because of his or her work-related injury or illness (Berry & Zaidman, 2013, p. 12).

Vocational rehabilitation - The sequential delivery and coordination of services by rehabilitation providers under a rehabilitation plan to achieve the goal of suitable gainful employment (Minnesota Rules 2011, part 5220.0100, subpart 37).

Workers' compensation - The social insurance system for industrial and work injury regulated primarily among the separate states, but regulated in certain specified occupations by the federal government (Matkin, 1985, p. 235).

Appendix B

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (*p*-value = .157)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-4.21(0.97)	18.85	.00	0.02		
Severity of Permanent Impairment		122.70	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.12(0.13)	0.85	.36	0.89	0.69	1.15
11% to 15%	-0.57(0.18)	9.98	.00	0.57	0.40	0.81
16% to 20%	-0.02(0.28)	0.01	.95	0.98	0.56	1.71
21% or more	0.42(0.27)	2.34	.13	1.52	0.89	2.59
Unknown	2.40(0.25)	94.14	.00	10.98	6.77	17.81
Pre-Injury AWW X Pre-Injury Industry		85.21	.00			
$500 or less X Natural res. and mining	0.35(0.70)	0.25	.62	1.42	0.36	5.64
$500 or less X Construction	0.89(0.34)	6.79	.01	2.43	1.25	4.74
$500 or less X Manufacturing	0.94(0.24)	15.26	.00	2.55	1.59	4.07
$500 or less X Trade, trans., and utilities	1.03(0.20)	27.44	.00	2.81	1.91	4.14
$500 or less X Information	0.64(0.83)	0.59	.44	1.89	0.37	9.65
$500 or less X Financial activities	-0.01(0.80)	0.00	1.00	1.00	0.21	4.75
$500 or less X Prof. and business services	0.76(0.32)	5.54	.02	2.13	1.14	4.00
$500 or less X Education and health serv.	1.36(0.30)	20.42	.00	3.91	2.16	7.06
$500 or less X Leisure and hospitality	1.04(0.66)	2.46	.12	2.82	0.77	10.28
$500 or less X Other services	0.95(0.53)	3.26	.07	2.59	0.92	7.30
$501 to $750 X Natural res. and mining	-0.13(0.71)	0.03	.86	0.88	0.22	3.57
$501 to $750 X Construction	0.34(0.20)	2.94	.09	1.40	0.95	2.06
$501 to $750 X Manufacturing	0.54(0.19)	8.40	.00	1.72	1.19	2.49
$501 to $750 X Trade, trans., and utilities	0.67(0.17)	14.77	.00	1.95	1.39	2.75
$501 to $750 X Information	0.43(0.71)	0.37	.54	1.54	0.39	6.12
$501 to $750 X Financial activities	-1.00(0.76)	1.74	.19	0.37	0.08	1.63

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
$501 to $750 X Prof. and business serv.	0.42(0.33)	1.57	.21	1.51	0.79	2.90
$501 to $750 X Educ. and health serv.	0.68(0.29)	5.56	.02	1.97	1.12	3.45
$501 to $750 X Leisure and hospitality	0.54(0.69)	0.60	.44	1.71	0.44	6.66
$501 to $750 X Other services	0.02(0.49)	0.00	.97	1.02	0.39	2.67
$751 to $1,000 X Natural res. and mining	0.41(0.81)	0.26	.61	1.51	0.31	7.42
$751 to $1,000 X Construction	-0.20(0.17)	1.40	.24	0.82	0.58	1.14
$751 to $1,000 X Manufacturing	0.08(0.20)	0.15	.70	1.08	0.73	1.59
$751 to $1,000 X Trade, trans., and util.	0.46(0.18)	6.65	.01	1.58	1.12	2.24
$751 to $1,000 X Information	1.31(0.81)	2.57	.11	3.69	0.75	18.21
$751 to $1,000 X Financial activities	-0.92(0.77)	1.41	.24	0.40	0.09	1.82
$751 to $1,000 X Prof. and business serv.	-0.13(0.36)	0.13	.72	0.88	0.43	1.79
$751 to $1,000 X Educ. and health serv.	0.45(0.32)	2.21	.15	1.57	0.85	2.92
$751 to $1,000 X Leisure and hospitality	0.52(0.81)	0.42	.52	1.69	0.34	8.29
$751 to $1,000 X Other services	-0.78(0.66)	1.41	.24	0.46	0.13	1.66
Attorney Involvement X Severity of PI		34.64	.00			
Attorney involved X 6% to 10%	0.04(0.17)	0.05	.83	1.04	0.75	1.44
Attorney involved X 11% to 15%	0.59(0.21)	7.74	.01	1.81	1.19	2.75
Attorney involved X 16% to 20%	0.49(0.33)	2.19	.14	1.63	0.85	3.09
Attorney involved X 21% or more	0.02(0.32)	0.00	.96	1.02	0.54	1.91
Attorney involved X Unknown	-1.11(0.26)	17.91	.00	0.33	0.20	0.55
Nature of Injury or Illness X Part of Body Affected		29.94	.23			
TI to M, T, L, J X Head and neck	-0.17(0.26)	0.42	.52	0.84	0.50	1.41
TI to M, T, L, J X Trunk and body sys.	-0.11(0.17)	0.45	.50	0.90	0.65	1.24
TI to M, T, L, J X Upper extremities	-0.66(0.20)	10.66	.00	0.52	0.35	0.77
TI to M, T, L, J X Lower extremities	-0.21(0.18)	1.44	.23	0.81	0.57	1.14

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
TI to M, T, L, J X Back	-0.12(0.16)	0.53	.47	0.89	0.65	1.22
W, B, and B X Head and neck	-0.13(0.43)	0.09	.77	0.88	0.38	2.04
W, B, and B X Trunk and body systems	0.58	2.12	.15	1.79	0.82	3.91
W, B, and B X Upper extremities	0.08	0.10	.75	1.09	0.65	1.83
W, B, and B X Lower extremities	0.04	0.02	.90	1.04	0.57	1.90
W, B, and B X Back	-0.37(0.50)	0.56	.45	0.69	0.26	1.83
Non-spec. P-R Cs X Head and neck	-0.24(0.50)	0.18	.67	0.79	0.26	2.39
Non-spec. P-R Cs X Trunk and body sys.	-0.71(0.32)	4.79	.03	0.49	0.26	0.93
Non-spec. P-R Cs X Upper extremities	-0.40(0.34)	1.43	.23	0.67	0.34	1.29
Non-spec. P-R Cs X Lower extremities	-0.68(0.36)	3.60	.06	0.51	0.25	1.02
Non-spec. P-R Cs X Back	-0.43(0.31)	1.87	.17	0.65	0.36	1.20
Mult. TI and disorders X Head and neck	0.37(0.75)	0.25	.62	1.45	0.33	6.30
Mult. TI and disorders X Trunk/body sys.	-20.07(-)	0.00	1.00	0.00	0.00	-
Mult. TI and disorders X Upper ext.	-0.17(0.66)	0.07	.80	0.84	0.23	3.09
Mult. TI and disorders X Lower ext.	-0.24(0.62)	0.15	.70	0.78	0.23	2.64
Mult. TI and disorders X Back	23.51(-)	0.00	1.00	-	0.00	-
Other and N-C inj. or ill. X Head/neck	0.29(0.38)	0.58	.45	1.33	0.64	2.80
Other/N-C inj. or ill. X Trunk/body sys.	-0.18(0.23)	0.60	.44	0.84	0.54	1.31
Other and N-C inj. or ill. X Upper ext.	0.03(0.19)	0.03	.87	1.03	0.71	1.49
Other and N-C inj. or ill. X Lower ext.	0.20(0.23)	0.75	.39	1.22	0.78	1.93
Other and N-C inj. or ill. X Back	0.61(0.38)	2.64	.11	1.84	0.88	3.86
Attorney Involvement X Job Tenure		27.89	.00			
Attorney involved X Less than 1 year	-0.88(0.17)	27.61	.00	0.41	0.30	0.58
Attorney involved X 1 to 5 years	-0.32(0.16)	3.88	.05	0.73	0.53	1.00

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Pre-Injury Industry		26.76	.00			
Natural resources and mining	-0.25(0.73)	0.12	.73	0.78	0.19	3.25
Construction	0.14(0.32)	0.19	.67	1.15	0.62	2.13
Manufacturing	-0.53(0.34)	2.45	.12	0.59	0.30	1.14
Trade, transportation, and utilities	-0.66(0.32)	4.25	.04	0.52	0.27	0.97
Information	-0.50(0.86)	0.34	.56	0.61	0.11	3.26
Financial activities	1.52(0.86)	3.08	.08	4.55	0.84	24.73
Professional and business services	-0.33(0.45)	0.53	.47	0.72	0.30	1.74
Education and health services	-1.09(0.42)	6.90	.01	0.34	0.15	0.76
Leisure and hospitality	-1.04(0.80)	1.67	.20	0.36	0.07	1.71
Other services	0.64(0.66)	0.93	.34	1.90	0.52	6.97
Public administration (base)	0.00					
Attorney Involvement						
Attorney involved	2.09(0.47)	20.01	.00	8.04	3.23	20.04
No attorney involved (base)	0.00					
Pre-Injury Industry X Sex		19.42	.04			
Natural resources and mining X Female	-0.03(0.72)	0.00	.97	0.98	0.24	3.98
Construction X Female	-0.35(0.43)	0.64	.42	0.71	0.30	1.65
Manufacturing X Female	0.21(0.22)	0.87	.35	1.23	0.80	1.91
Trade, trans., and utilities X Female	0.20(0.22)	0.77	.38	1.22	0.79	1.89
Information X Female	1.35(0.63)	4.54	.03	3.84	1.11	13.27
Financial activities X Female	-0.08(0.49)	0.03	.87	0.93	0.36	2.40
Prof. and business serv. X Female	0.41(0.30)	1.89	.17	1.51	0.84	2.72
Education and health services X Female	0.49(0.24)	3.98	.05	1.63	1.01	2.62
Leisure and hospitality X Female	1.17(0.35)	11.38	.00	3.23	1.63	6.37

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Other services X female	0.29(0.45)	0.43	.51	1.34	0.56	3.23
Age		17.26	.00			
18 to 24 years (base)	0.00					
25 to 34 years	1.46(0.95)	2.38	.12	4.32	0.67	27.67
35 to 44 years	1.51(0.93)	2.61	.11	4.51	0.73	28.02
45 to 54 years	1.32(0.93)	2.01	.16	3.74	0.60	23.15
55 to 64 years	2.01(0.93)	4.65	.03	7.47	1.20	46.49
Pre-Injury Industry X Residence		16.90	.08			
Natural res. and mining X Metropolitan	-0.48(0.50)	0.94	.33	0.62	0.24	1.63
Construction X Metropolitan	0.30(0.15)	3.98	.05	1.35	1.01	1.80
Manufacturing X Metropolitan	0.17(0.13)	1.75	.19	1.19	0.92	1.53
Trade, trans., and util. X Metropolitan	0.09(0.13)	0.52	.47	1.10	0.85	1.42
Information X Metropolitan	-0.51(0.64)	0.63	.43	0.60	0.17	2.11
Financial activities X Metropolitan	-1.28(0.63)	4.14	.04	0.28	0.08	0.95
Prof. and business serv. X Metropolitan	0.40(0.23)	2.89	.09	1.49	0.94	2.34
Education and health serv. X Metropolitan	0.08(0.15)	0.28	.59	1.09	0.80	1.47
Leisure and hospitality X Metropolitan	0.48(0.36)	1.79	.18	1.62	0.80	3.29
Other services X Metropolitan	-0.10(0.47)	0.04	.83	0.91	0.36	2.29
Education		16.04	.00			
Less than high school	0.44(0.15)	8.08	.00	1.55	1.15	2.09
High school or general equiv. diploma	0.07(0.14)	0.28	.60	1.08	0.82	1.41
Some post-sec. courses but no degree	0.11(0.14)	0.60	.44	1.11	0.85	1.46
Post-sec. vocational/technical program	0.17(0.14)	1.59	.21	1.19	0.91	1.55

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Bachelor's degree or higher (base)	0.00					
Attorney Involvement X Pre-Injury Industry		15.11	.13			
Attorney inv. X Nat. res. and mining	0.47(0.63)	0.56	.46	1.60	0.47	5.49
Attorney inv. X Construction	-0.20(0.63)	0.29	.59	0.82	0.40	1.68
Attorney inv. X Manufacturing	0.25(0.36)	0.47	.49	1.29	0.63	2.62
Attorney inv. X Trade, trans., and utilities	0.29(0.36)	0.65	.42	1.34	0.66	2.71
Attorney inv. X Information	0.07(0.67)	0.01	.92	1.07	0.29	3.97
Attorney inv. X Financial activities	0.91(0.62)	2.17	.14	2.49	0.74	8.39
Attorney inv. X Prof. and business serv.	-0.19(0.41)	0.06	.81	0.91	0.41	2.03
Attorney inv. X Educ. and health serv.	0.19(0.37)	0.26	.61	1.21	0.59	2.50
Attorney inv. X Leisure and hospitality	-0.20(0.46)	0.20	.66	0.82	0.33	2.00
Attorney inv. X Other services	-0.54(0.49)	1.21	.27	0.58	0.22	1.53
Age X Job Tenure		13.71	.09			
25 to 34 years X Less than 1 year	-1.09(0.93)	1.39	.24	0.34	0.06	2.06
25 to 34 years X 1 to 5 years	-1.22(0.94)	1.70	.19	0.30	0.05	1.85
35 to 44 years X Less than 1 year	-0.95(0.91)	1.09	.30	0.39	0.07	2.30
35 to 44 years X 1 to 5 years	-0.89(0.92)	0.92	.34	0.41	0.07	2.51
45 to 54 years X Less than 1 year	-0.89(0.91)	0.96	.33	0.41	0.07	2.43
45 to 54 years X 1 to 5 years	-0.64(0.92)	0.48	.49	0.53	0.09	3.21
55 to 64 years X Less than 1 year	-1.36(0.92)	2.20	.14	0.26	0.04	1.55
55 to 64 years X 1 to 5 years	-0.83(0.92)	0.81	.37	0.44	0.07	2.66
Age X Pre-Existing Claim Status		11.85	.02			
25 to 34 years X One + prior WC claims	-0.11(0.16)	0.50	.48	0.89	0.65	1.22
35 to 44 years X One + prior WC claims	0.06(0.11)	0.26	.61	1.06	0.85	1.32

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
45 to 54 years X One + prior WC claims	0.16(0.10)	2.36	.12	1.17	0.96	1.44
55 to 64 years X One + prior WC claims	0.37(0.13)	8.81	.00	1.45	1.13	1.85
Job Tenure		11.26	.00			
Less than 1 year	1.99(0.91)	4.80	.03	7.33	1.23	43.55
1 to 5 years	1.12(0.92)	1.49	.22	3.07	0.51	18.63
More than 5 years (base)	0.00					
Nature of Injury or Illness		10.90	.05			
TI to bones, nerves, spinal cord (base)	0.00					
TI to muscles, tendons, ligaments, joints	0.42(0.17)	6.00	.01	1.52	1.09	2.14
Wounds, bruises, and burns	0.13(0.24)	0.28	.60	1.14	0.71	1.81
Non-specified pain-related conditions	0.79(0.31)	6.70	.01	2.20	1.21	4.00
Multiple traumatic injuries and disorders	0.23(0.20)	1.38	.24	1.26	0.86	1.84
Other and non-classifiable inj. or ill.	0.22(0.16)	1.84	.18	1.24	0.91	1.69
Pre-Injury Average Weekly Wage X Sex		9.66	.02			
$500 or less X Female	-0.73(0.23)	9.65	.00	0.48	0.31	0.77
$501 to $750 X Female	-0.47(0.22)	4.59	.03	0.63	0.41	0.96
$751 to $1,000 X Female	-0.42(0.23)	3.29	.07	0.66	0.42	1.03
Age X Attorney Involvement		9.46	.05			
25 to 34 years X Attorney involved	-0.11(0.35)	0.09	.77	0.90	0.45	1.79
35 to 44 years X Attorney involved	-0.32(0.33)	0.94	.33	0.73	0.38	1.39
45 to 54 years X Attorney involved	0.05(0.33)	0.03	.87	1.05	0.56	2.00
55 to 64 years X Attorney involved	-0.43(0.34)	1.61	.21	0.65	0.34	1.26

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval; AWW = average weekly wage; Prof. = professional; util. = utilities; serv. = services; PI = permanent impairment; TI = traumatic injuries; M, T, L, J = muscles, tendons, ligaments, joints; W,B, and B = wounds, bruises and bones; Non-spec. P-R Cs = non-specified pain-related conditions; Multi. TI = multiple traumatic injuries; Other and N-C inj. or ill. = other and non-classifiable injuries or illnesses; sys. = systems; Nat. res. = natural resources; trans. = transportation; Educ. = education; Attorney inv. = attorney involved; ext. = extremities; equiv. = equivalency; post-sec. = post-secondary; One + = one or more; WC = workers' compensation.

Appendix C

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (*p*-value = .157)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-3.14(0.25)	157.84	.00	0.04		
Attorney Involvement						
Attorney involved	1.70(0.07)	660.39	.00	5.46	4.79	6.21
No attorney involved (base)	0.00					
Severity of Permanent Impairment		409.24	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.06(0.08)	0.51	.47	0.94	0.81	1.11
11% to 15%	-0.09(0.09)	0.93	.33	0.91	0.76	1.10
16% to 20%	0.36(0.14)	6.84	.01	1.44	1.10	1.88
21% or more	0.46(0.14)	10.51	.00	1.59	1.20	2.10
Unknown	1.36(0.08)	276.98	.00	3.90	3.32	4.57
Age		70.93	.00			
18 to 24 years (base)	0.00					
25 to 34 years	0.22(0.15)	2.14	.14	1.25	0.93	1.69
35 to 44 years	0.34(0.15)	5.21	.02	1.40	1.05	1.88
45 to 54 years	0.57(0.15)	14.77	.00	1.77	1.32	2.36
55 to 64 years	0.91(0.16)	34.96	.00	2.50	1.84	3.38
Pre-Injury Average Weekly Wage		64.12	.00			
$500 or less	0.71(0.10)	51.36	.00	2.03	1.67	2.46
$501 to $750	0.37(0.08)	19.50	.00	1.45	1.23	1.71
$751 to $1,000	0.05(0.08)	0.29	.59	1.05	0.89	1.23
$1,001 or more (base)	0.00					

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Job Tenure		27.42	.00			
Less than 1 year	0.40(0.08)	25.03	.00	1.49	1.27	1.74
1 to 5 years	0.09(0.07)	1.55	.22	1.09	0.95	1.26
More than 5 years (base)	0.00					
Pre-Injury Industry		23.50	.01			
Natural resources and mining	-0.21(0.28)	0.56	.46	0.81	0.47	1.41
Construction	0.26(0.18)	2.21	.14	1.30	0.92	1.85
Manufacturing	-0.00(0.17)	0.00	.98	1.00	0.71	1.40
Trade, transportation, and utilities	-0.01(0.17)	0.01	.94	0.99	0.71	1.38
Information	-0.27(0.30)	0.82	.36	0.76	0.42	1.37
Financial activities	0.00(0.25)	0.00	.99	1.00	0.61	1.65
Professional and business services	-0.02(0.19)	0.01	.91	0.98	0.67	1.43
Education and health services	-0.26(0.18)	2.17	.14	0.77	0.54	1.09
Leisure and hospitality	-0.02(0.22)	0.00	.94	0.98	0.64	1.51
Other services	0.14(0.24)	0.35	.56	1.15	0.72	1.85
Public administration (base)	0.00					
Education		16.56	.00			
Less than high school	0.41(0.15)	7.75	.01	1.51	1.13	2.02
High school or general equiv. diploma	0.05(0.13)	0.13	.72	1.05	0.81	1.36
Some post-sec. courses but no degree	0.10(0.13)	0.55	.46	1.10	0.85	1.43
Post-sec. vocational/technical program	0.17(0.13)	1.56	.21	1.18	0.91	1.53
Bachelor’s degree or higher (base)	0.00					
Pre-Existing Claim Status						
One or more prior WC claims	0.16(0.06)	7.01	.01	1.17	1.04	1.31

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .157)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
No prior WC claim (base)	0.00					
Residence						
Metropolitan	0.15(0.06)	5.73	.02	1.16	1.03	1.31
Non-metropolitan (base)	0.00					
Sex						
Male (base)	0.00					
Female	-0.15(0.07)	4.44	.04	0.86	0.75	0.99
Marital Status						
Married (base)	0.00					
Not married	0.10(0.06)	3.03	.08	1.11	0.99	1.24

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval; equiv. = equivalency; post-sec. = post-secondary; WC = workers' compensation.

Appendix D

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (*p*-value = .05)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-3.10(0.26)	143.36	.00	0.05		
Attorney Involvement						
Attorney involved	1.99(0.14)	211.00	.00	7.30	5.58	9.54
No attorney involved (base)	0.00					
Severity of Permanent Impairment		126.63	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.08(0.13)	0.45	.50	0.92	0.72	1.18
11% to 15%	-0.48(0.17)	7.72	.01	0.62	0.44	0.87
16% to 20%	0.02(0.28)	0.01	.95	1.02	0.59	1.76
21% or more	0.47(0.27)	3.12	.08	1.60	0.95	2.70
Unknown	2.37(0.24)	101.68	.00	10.68	6.74	16.92
Pre-Injury AWW X Pre-Injury Industry		86.90	.00			
$500 or less X Natural res. and mining	0.57(0.67)	0.72	.40	1.76	0.48	6.51
$500 or less X Construction	0.83(0.34)	5.94	.02	2.29	1.18	4.45
$500 or less X Manufacturing	0.93(0.23)	16.07	.00	2.54	1.61	4.00
$500 or less X Trade, trans., and utilities	1.01(0.19)	27.55	.00	2.75	1.88	4.00
$500 or less X Information	0.80(0.82)	0.96	.33	2.23	0.45	11.04
$500 or less X Financial activities	0.05(0.70)	0.01	.94	1.05	0.27	4.12
$500 or less X Prof. and business serv.	0.75(0.32)	5.38	.02	2.11	1.12	3.97
$500 or less X Education and health serv.	1.32(0.30)	19.90	.00	3.74	2.09	6.66
$500 or less X Leisure and hospitality	1.13(0.67)	2.84	.09	3.08	0.83	11.42
$500 or less X Other services	1.00(0.54)	3.43	.06	2.72	0.94	7.85
$501 to $750 X Natural res. and mining	0.18(0.66)	0.08	.78	1.20	0.33	4.34
$501 to $750 X Construction	0.32(0.20)	2.70	.10	1.38	0.94	2.04

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
$501 to $750 X Manufacturing	0.59(0.18)	10.30	.00	1.80	1.26	2.58
$501 to $750 X Trade, trans., and util.	0.69(0.17)	16.20	.00	1.99	1.42	2.78
$501 to $750 X Information	0.53(0.69)	0.59	.44	1.69	0.44	6.52
$501 to $750 X Financial activities	-0.60(0.63)	0.89	.35	0.55	0.16	1.90
$501 to $750 X Prof. and business serv.	0.44(0.33)	1.73	.19	1.55	0.81	2.97
$501 to $750 X Educ. and health serv.	0.71(0.28)	6.38	.01	2.04	1.17	3.53
$501 to $750 X Leisure and hospitality	0.73(0.70)	1.08	.30	2.07	0.52	8.19
$501 to $750 X Other services	0.09(0.51)	0.03	.86	1.10	0.40	3.00
$751 to $1,000 X Natural res. and mining	0.54(0.76)	0.51	.48	1.72	0.39	7.64
$751 to $1,000 X Construction	-0.26(0.17)	2.37	.12	0.77	0.55	1.07
$751 to $1,000 X Manufacturing	0.09(0.19)	0.22	.64	1.09	0.75	1.60
$751 to $1,000 X Trade, trans., and util.	0.46(0.17)	7.12	.01	1.59	1.13	2.24
$751 to $1,000 X Information	1.43(0.79)	3.26	.07	4.20	0.88	19.91
$751 to $1,000 X Financial activities	-0.69(0.67)	1.09	.30	0.50	0.14	1.84
$751 to $1,000 X Prof. and business serv.	-0.16(0.36)	0.19	.66	0.85	0.42	1.74
$751 to $1,000 X Educ. and health serv.	0.47(0.31)	2.25	.13	1.59	0.87	2.93
$751 to $1,000 X Leisure and hospitality	0.76(0.83)	0.84	.36	2.13	0.42	10.77
$751 to $1,000 X Other services	-0.70(0.68)	1.06	.30	0.50	0.13	1.88
Job Tenure		53.69	.00			
Less than 1 year	0.96(0.13)	51.99	.00	2.60	2.01	3.37
1 to 5 years	0.25(0.13)	3.57	.06	1.28	0.99	1.67
More than 5 years (base)	0.00					
Attorney Involvement X Severity of PI		34.11	.00			
Attorney involved X 6% to 10%	0.05(0.16)	0.09	.76	1.05	0.76	1.45
Attorney involved X 11% to 15%	0.56(0.21)	7.06	.01	1.75	1.16	2.64

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Attorney involved X 16% to 20%	0.50(0.33)	2.35	.13	1.65	0.87	3.11
Attorney involved X 21% or more	0.03(0.32)	0.01	.93	1.03	0.55	1.91
Attorney involved X Unknown	-1.06(0.25)	17.73	.00	0.35	0.21	0.57
Pre-Injury Industry		31.49	.00			
Natural resources and mining	-0.39(0.54)	0.53	.47	0.68	0.24	1.94
Construction	0.19(0.20)	0.90	.34	1.21	0.82	1.77
Manufacturing	-0.28(0.23)	1.46	.23	0.76	0.48	1.19
Trade, transportation, and utilities	-0.42(0.21)	3.83	.05	0.66	0.43	1.00
Information	-0.96(0.56)	2.98	.08	0.38	0.13	1.14
Financial activities	0.78(0.57)	1.90	.17	2.18	0.72	6.59
Professional and business services	-0.16(0.32)	0.25	.62	0.85	0.45	1.60
Education and health services	-0.92(0.32)	8.05	.01	0.40	0.21	0.75
Leisure and hospitality	-0.97(0.68)	2.02	.16	0.38	0.10	1.44
Other services	0.13(0.45)	0.09	.77	1.14	0.48	2.72
Public administration (base)	0.00					
Attorney Involvement X Job Tenure		29.96	.00			
Attorney involved X Less than 1 year	-0.83(0.15)	29.68	.00	0.44	0.33	0.59
Attorney involved X 1 to 5 years	-0.28(0.15)	3.27	.07	0.76	0.56	1.02
Age		24.74	.00			
18 to 24 years (base)	0.00					
25 to 34 years	0.28(0.16)	3.12	.08	1.33	0.97	1.81
35 to 44 years	0.36(0.15)	5.42	.02	1.43	1.06	1.94
45 to 54 years	0.53(0.15)	11.88	.00	1.70	1.26	2.30
55 to 64 years	0.74(0.17)	20.00	.00	2.09	1.51	2.89

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Pre-Injury Industry X Sex		18.67	.05			
Natural resources and mining X Female	0.23(0.66)	0.12	.73	1.26	0.34	4.62
Construction X Female	-0.29(0.43)	0.45	.50	0.75	0.32	1.75
Manufacturing X Female	0.22(0.22)	0.98	.32	1.24	0.81	1.91
Trade, trans., and utilities X Female	0.22(0.22)	0.98	.32	1.24	0.81	1.90
Information X Female	1.32(0.64)	4.29	.04	3.73	1.07	12.96
Financial activities X Female	-0.13(0.45)	0.09	.77	0.88	0.37	2.11
Prof. and business serv. X Female	0.40(0.30)	1.82	.18	1.49	0.83	2.67
Education and health serv. X Female	0.50(0.24)	4.31	.04	1.64	1.03	2.63
Leisure and hospitality X Female	1.15(0.35)	10.98	.00	3.16	1.60	6.23
Other services X female	0.20(0.45)	0.20	.66	1.22	0.50	2.97
Education		15.87	.00			
Less than high school	0.43(0.15)	7.90	.01	1.53	1.14	2.06
High school or general equiv. diploma	0.07(0.14)	0.26	.61	1.07	0.82	1.40
Some post-sec. courses but no degree	0.11(0.14)	0.69	.41	1.12	0.86	1.47
Post-sec. vocational/technical program	0.18(0.14)	1.80	.18	1.20	0.92	1.56
Bachelor's degree or higher (base)	0.00					
Age X Pre-Existing Claim Status		13.65	.01			
25 to 34 years X One + prior WC claims	-0.06(0.16)	0.15	.70	0.94	0.69	1.28
35 to 44 years X One + prior WC claims	0.07(0.11)	0.34	.56	1.07	0.86	1.33
45 to 54 years X One + prior WC claims	0.16(0.10)	2.67	.10	1.18	0.97	1.44
55 to 64 years X One + prior WC claims	0.41(0.13)	10.64	.00	1.50	1.18	1.92
Pre-Injury Average Weekly Wage X Sex		8.92	.03			
$500 or less X Female	-0.68(0.23)	8.67	.00	0.51	0.33	0.80

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main and First-Order Interaction Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
$501 to $750 X Female	-0.50(0.22)	5.43	.02	0.61	0.40	0.92
$751 to $1,000 X Female	-0.43(0.23)	3.54	.06	0.65	0.42	1.02
Residence						
Metropolitan	0.15(0.06)	5.61	.02	1.16	1.03	1.31
Non-metropolitan (base)	0.00					

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval; AWW = average weekly wage; res. = resources; trans. = transportation; Prof. = professional; serv. = services; util. = utilities; Educ. = education; PI = permanent impairment; equiv. = equivalent; post-sec. = post-secondary; One + = one or more; WC = workers' compensation.

Appendix E

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (*p*-value = .05)

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Constant	-3.07(0.25)	155.19	.00	0.05		
Attorney Involvement						
Attorney involved	1.70(0.07)	660.36	.00	5.45	4.79	6.21
No attorney involved (base)	0.00					
Severity of Permanent Impairment		408.91	.00			
1% to 5% (base)	0.00					
6% to 10%	-0.06(0.08)	0.54	.46	0.94	0.81	1.10
11% to 15%	-0.09(0.09)	0.95	.33	0.91	0.76	1.10
16% to 20%	0.36(0.14)	6.61	.01	1.43	1.09	1.87
21% or more	0.47(0.14)	10.67	.00	1.59	1.21	2.10
Unknown	1.36(0.08)	276.44	.00	3.89	3.31	4.56
Age		68.31	.00			
18 to 24 years (base)	0.00					
25 to 34 years	0.20(0.15)	1.72	.19	1.22	0.91	1.65
35 to 44 years	0.30(0.15)	4.19	.04	1.35	1.01	1.80
45 to 54 years	0.53(0.15)	13.07	.00	1.70	1.27	2.26
55 to 64 years	0.87(0.15)	32.55	.00	2.39	1.77	3.22
Pre-Injury Average Weekly Wage		64.50	.00			
$500 or less	0.71(0.10)	51.94	.00	2.04	1.68	2.47
$501 to $750	0.38(0.08)	19.89	.00	1.46	1.24	1.72
$751 to $1,000	0.05(0.08)	0.34	.56	1.05	0.89	1.24
$1,001 or more (base)	0.00					

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Job Tenure		28.91	.00			
Less than 1 year	0.41(0.08)	26.53	.00	1.50	1.29	1.76
1 to 5 years	0.09(0.07)	1.74	.19	1.10	0.96	1.26
More than 5 years (base)	0.00					
Pre-Injury Industry		23.46	.01			
Natural resources and mining	-0.22(0.28)	0.58	.45	0.81	0.46	1.40
Construction	0.27(0.18)	2.28	.13	1.31	0.92	1.85
Manufacturing	-0.00(0.17)	0.00	1.00	1.00	0.71	1.41
Trade, transportation, and utilities	-0.01(0.17)	0.00	.95	0.99	0.71	1.38
Information	-0.26(0.30)	0.78	.38	0.77	0.43	1.38
Financial activities	0.00(0.25)	0.00	.99	1.00	0.61	1.65
Professional and business services	-0.02(0.19)	0.01	.94	0.99	0.67	1.44
Education and health services	-0.26(0.18)	2.09	.15	0.77	0.54	1.10
Leisure and hospitality	-0.01(0.22)	0.00	.96	0.99	0.65	1.52
Other services	0.15(0.24)	0.41	.52	1.17	0.73	1.87
Public administration (base)	0.00					
Education		16.46	.00			
Less than high school	0.41(0.15)	7.69	.01	1.51	1.13	2.02
High school or general equiv. diploma	0.05(0.13)	0.12	.73	1.05	0.81	1.36
Some post-sec. courses but no degree	0.10(0.13)	0.57	.45	1.11	0.85	1.44
Post-sec. vocational/technical program	0.16(0.13)	1.56	.21	1.18	0.91	1.53

Logistic Regression Analysis of RTW Status as of Claim Closure as a Function of the Main Effects of Medical, Individual, and Workplace Factors Using the Development Dataset (p-value = .05)

Predictor Variable	β(SE)	Wald χ^2	*P*-Value	Odds Ratio	95% CI for Odds Ratio Lower	Upper
Bachelor's degree or higher (base)	0.00					
Pre-Existing Claim Status						
One or more prior WC claims	0.16(0.06)	7.29	.01	1.17	1.05	1.32
No prior WC claim (base)	0.00					
Residence						
Metropolitan	0.15(0.06)	6.26	.01	1.17	1.03	1.32
Non-metropolitan (base)	0.00					
Sex						
Male (base)	0.00					
Female	-0.14(0.07)	3.97	.05	0.87	0.75	1.00

Note. The reference category for the dependent variable is successful RTW as of claim closure. SE = standard error; CI = confidence interval; equiv. = equivalent; post-sec. = post-secondary; WC = workers' compensation.

Vita

A. Bentley Hankins was born in Johnson City, Tennessee to Norman and Marilyn Hankins. He is married to Erin Hankins and resides in Jonesborough, Tennessee. Bentley earned a Bachelor of Science degree in Economics from Clemson University and a Master of Science degree in Rehabilitation Counseling from the University of Tennessee-Knoxville. He is certified as a rehabilitation counselor (CRC) and a vocational evaluation specialist (CVE). Bentley operates a private vocational rehabilitation consulting practice in which he primarily provides litigation support to assist triers of fact in evaluating the extent of vocational disability and/or economic loss that an individual has sustained as a result of medical impairment. This includes but is not limited to his role as a vocational expert with the Social Security Administration's Office of Disability Adjudication and Review where he assists administrative law judges in determining claimants' residual employability. He has also served as a vocational expert in several other types of employment-related litigation (e.g., workers' compensation; personal injury; medical malpractice; wrongful death; marital dissolution; long-term disability). In addition, Bentley provides rehabilitation counseling services to members of the general public requesting career guidance and to workers' compensation and long-term disability recipients needing assistance defining vocational goals, acquiring job skills, and returning to work.