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# Permanent Injury and the Disability-Mitigating Effects of Education

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## Abstract

Using data from Ontario, we study the extent to which education mitigates the realized work-disabling effects of permanent occupational injury. Focusing first on the rates of post-injury employment, our results suggest that education has a strong disability-mitigating effect in cases of knee and shoulder injuries, but a smaller effect where workers have experienced permanent back or wrist/finger injuries. A comparison of pre- and post-injury occupations then reveals that education mitigates disability not so much by facilitating job shifting, but rather by enabling the individual to return to the pre-injury occupation. These latter results suggest that education may mitigate disability somewhat indirectly by facilitating the accumulation of occupation-specific human capital that, in turn, compensates for the effects of physical impairment.

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# 1 Introduction

When an occupational injury leaves a worker permanently and partially impaired, concerns regarding the resulting welfare impact arise not so much from the *impairment* directly, but from the possibility that the impairment will translate into permanent work-related *disability* that has the effect of reducing productivity and/or increasing the disutility of work itself.[1] In either event, the result for the affected individual will be a reduction in the net value of work, and therefore a diminished capacity to enhance his or her own welfare through employment.

Despite these concerns, the impairment-disability relationship is not well understood. Disability, much like the productivity or work disutility it affects, is unobservable to the econometrician and can only be inferred from observed, post-injury labor market experiences. In examining those experiences, however, previous studies have been interested not so much in inferring the extent of disability, but rather in studying a number of other important policy issues – namely, the potential work-disincentive effects of workers compensation benefits (Worrall and Butler, 1985; Johnson and Ondrich, 1990; and Campolieti, 2001) and the employment effects of workplace accommodations (Burkhauser, Butler, and Kim, 1995).[2,3]

Those studies have, of course, necessarily controlled for injury type and have found evidence of significant differences in post-injury employment outcomes across impairment categories. But their respective focuses have abstracted from the possibility that the disabling effects a permanent injury may vary systematically not just across, but also within, impairment groups. For while a given impairment and its associated physical limitations are clinically absolute, the realized work-disabling effects that result may differ across individuals who differ in terms of their ability to adapt to those limitations (Cater, 2000).

In this paper, we extend our understanding of the impairment-disability relationship. It is widely understood that the returns to education take a number of forms, including an improved ability to learn new skills on the job and an expansion of occupational options. Because education may then facilitate functional adaptation within the context of a given job, or because it may facilitate shifting to a job in which an impairments physical limitations are less functionally relevant, we consider the question of whether, and to what extent, education serves to mitigate the realized work-disabling effects of permanent occupational injury. If and where this occurs, education may be an important part of a strategy that serves to mitigate the welfare effects of occupational injury, in much the same way as workplace accommodations, but more portably, without the moral hazard associated with direct income replacement.

Using data from Ontario, we examine the post-injury employment rates of a sample of permanently impaired workers, each of whom experienced one of the four most commonly occurring injury types. We find evidence that higher levels of education have a dramatic compensating effect in cases of knee and shoulder injuries. For permanent wrist/finger injuries, our results suggest that education plays a smaller role, although these injuries do not appear to be as generally disabling

[1] Despite often being used interchangeably, an important distinction exists between these two concepts. The World Health Organization (1980) defines an *impairment* as a psychological or anatomical loss or some other abnormality. A *disability*, by contrast, is a restriction on, or lack of, ability to perform an activity in the manner or within the range considered normal.

[2] For surveys of the literature that has examined the impact of benefits on work incentives, see Gunderson and Hyatt (1998) and Fortin and Lanoie (1999).

[3] Concerns regarding potential work disincentive effects are rooted in workers' compensation systems' historical focus on income replacement as a means of mitigating welfare loss from injury, while interest in the effects of accommodation is rooted in legislators' more recent focus on work and work environment modifications as a way of enabling the individual to maintain productive employment.

as our other impairment categories. Permanent back injuries are the most seriously disabling of our impairment categories, and education appears to do relatively little to compensate for their work-limiting effects.

# 2 Theory and Empirical Method

The theoretical basis for our study is a model of post-injury adaptive behavior and employment, described in detail in Cater (2000). Following a permanently impairing occupational injury, an individual will exert adaptive effort in an attempt to maximize the utility derived from his 'best' employment option; this may involve adapting his approach to the performance of a particular set of tasks or shifting to a job in which his physical limitations are less functionally relevant. Individual characteristics that facilitate either sort of adaptation then serve to mitigate the negative impact of impairment on the net utility derived from employment.

A basic empirical specification for studying the latent utility derived from post-injury employment, similar to that found elsewhere in the literature, would be:

$$y^*_{it} = X_{it}\beta + I_i\gamma + T_{it}\delta + E_i\eta + (I_i \times T_i)\zeta + (T_i \times E_i)\phi + e_{it}, \tag{1}$$

where $y^*_{it}$ is the latent utility index individual $i$ derives from her best employment option during post-injury period $t$; $X_{it}$ is a vector of standard demographic and labour market variables influencing the labour supply decision; $I_i$ is a vector of impairment-type indicators; $T_{it}$ is a vector of non-linear time variables that control for any effects of time on individual $i$'s state of post-injury recovery; $E_i$ describes the individual's education; $I_i \times T_i$ is an interactive term that accounts for any differences in the rates of recovery across injury types; $T_i \times E_i$ is an interactive term that captures any effects that education may have on the rate at which an individual can re-establish and maintain employment after any sort of disruption; $\beta$, $\gamma$, $\delta$, $\eta$, $\zeta$, and $\phi$ are unobservable parameter vectors to be estimated; and $e_{it}$ is an error term.

For our purposes, however, the specification in (1) is insufficient in that it is capable of capturing only the mean "disabling" effect of impairment types and, independently, the mean employment utility effects of education. What we wish to test is the hypothesis that education and impairment interact to determine the realized degree of work-related disability. To do so, we augment the specification in (1) as follows:

$$\begin{aligned} y^*_{it} = X_{it}\beta + I_i\gamma + T_{it}\delta + E_i\eta + (I_i \times T_i)\zeta + (T_i \times E_i)\phi \\ + (I_i \times E_i)\theta + (I_i \times T_{it} \times E_i)\lambda + e_{it}, \end{aligned} \tag{2}$$

where interactive terms $I_i \times E_i$ and $I_i \times T_{it} \times E_i$ account for possible ways in which the effects of education on the value of employment may be different for across impairment types and in which those effects may be influenced by the state of the individual's recovery, and where $\theta$ and $\lambda$ are additional parameter vectors to be estimated.

Some care must be taken in interpreting the parameter estimates in the specification described in equation (2). While education may well have the disability-mitigating effects we hypothesize here, it is a stylized fact that education also has a more general effect on the value of employment for any and all workers. If we were to consider a sample comprised of both impaired *and* unimpaired workers, the general effects of education would be captured by the parameter vectors $\eta$ and $\phi$, while the disability-mitigating effects would be separately captured by $\theta$ and $\lambda$.[4] The data that will be used here and that will be described in detail in the next section, however, capture the experiences of a sample of only impaired workers. As such, the general effects of education cannot be estimated and separated from the disability-mitigating effects. What we can do, however, is interpret $\eta$ and $\phi$ as describing a combination of general and disability-mitigating effects for our reference (i.e., omitted) impairment category, and, because the general effects of education will be common across injury types, interpret the vectors $\theta$ and $\lambda$ as measuring the extent to which the disability-mitigating effects of education of the various impairment categories differ from those for the reference category.

We further decompose the error term in specification (2) so that

$$e_{it} = \alpha_i + \varepsilon_{it}, \qquad (3)$$
$$\text{where } \alpha_i \sim i.i.d.N(0, \sigma_\alpha^2) \text{ and } \varepsilon_{it} \sim i.i.d.N(0,1).$$

This specification allows us to account for unobserved heterogeneity between individuals in the form of an individual-specific term, $\alpha_i$, that captures permanent latent differences in the utility individual $i$ derives from employment.

Assuming a simple decision rule – individual $i$ chooses to work during her $t^{th}$ post-injury period if and only if $y_{it}^* \geq 0$ – his/her total contribution to the sample likelihood can be written as:

$$L_i(\beta, \gamma, \delta, \zeta, \eta, \theta, \lambda, \sigma_\alpha^2) = \int_{-\infty}^{\infty} \prod_{t=1}^{T_i} f_\alpha(\alpha_i) \left[ \Phi_{it}^{y_{it}} (1 - \Phi_{it})^{(1-y_{it})} \right] d\alpha_i, \qquad (4)$$

where $f_\alpha$ is $\alpha_i$'s normal probability density function, $\Phi$ is the standard normal cumulative distribution function, and $\Phi_{it} = \Phi(X_{it}\beta + I_i\gamma + T_{it}\delta + (I_i \times T_i)\zeta + E_i\eta + (I_i \times E_i)\theta + (I_i \times T_{it} \times E_i)\lambda + \alpha_i)$. Following Butler and Moffitt (1982), the one-dimensional integrals in equation (5) will be evaluated using a quadrature rule.

# 3 Data

Workers who were covered by the Ontario Workers' Compensation Board, and who experienced permanent occupational injuries prior to the 1990s, were eligible to receive so-called *Permanent Disability Benefits (PDB)*. Upon reaching the point of maximum medical improvement, a physical examination by a Board physician would be used to assign the worker a "permanent disability rating" that would, in turn, be used to set the worker's *PDB* level.

The data analyzed in this paper are drawn from the Ontario Workers' Compensation Board's (OWCB) *Survey of Workers with Permanent Impairments*. Potential Survey respondents included all individuals who had experienced a permanent occupational injury and who, having reached the point of maximum medical recovery, were scheduled, between June 1989 and August 1990, to be

[4] This would amount to a sort of difference-in-differences approach, where the single, general effect of education experienced by the unimpaired workers would be subtracted from the two effects embedded in the data for the impaired workers to effectively isolate the disability-mitigating effect of education.

assessed by a Board physician for the purposes described above. Following their medical assessment, each potential respondent could voluntarily choose to participate in the Survey interview.[5]

Among other things, the Survey captured details on more than 11,000 respondents' demographics and post-injury employment spells. Survey data were supplemented with OWCB administrative data on each respondent's part-of-body impaired and time-of-accident earnings.

Two legislative features are noteworthy. First, a potential problem with attempting to infer disability from the observed labour market choices of permanently injured workers lies in a typical feature of workers' compensation benefit systems. In particular, when more generous benefits are paid for impairments that are more clinically severe and perhaps more work-disabling, it is difficult to disentangle the work-disabling effects of the injury from the work-disincentive effects of the benefits themselves. Between their accident date and their point of maximum medical recovery (and Survey interview), however, respondents were eligible to receive temporary disability benefits which were set at the same percentage of time-of-accident earnings, regardless of their injury type and severity. As a result, during the injury-to-Survey period, conditional on time-of-accident earnings and other things being equal, any differences in employment experiences across impairment categories can be attributed strictly to differences in their work-disabling effects.

Second, all Survey participants were injured prior to legislative amendments to the Ontario Workers' Compensation Act requiring time-of-accident employers to re-employ and accommodate injured workers.[6] As such, none of the legislation's provisions applied to any Survey participant. The observed post-injury employment experiences can, therefore, be viewed as arising strictly out of worker preferences and market mechanisms.[7]

We restricted our sample to men whose injuries occurred in 1980 or later; who were aged 18 to 59 at the time of their injury; who had experienced either a back, hand, shoulder, or knee injury; whose information on our control variables was complete, and whose retrospective reports of their employment history between their accident and interview dates contained no missing information or inconsistencies. This narrowed our sample to 2617 individuals.

The Survey asked respondents to identify the start- and end-months of any and all post-injury jobs. We used this information to construct a vector describing the employment status of each individual in each of their observed post-injury months. In determining employment status, we considered an individual to be employed during any month in which a job began, was ongoing, or came to an end. In total, we observe 85832 post-injury months – an average of almost 33 months per individual. Individuals in our sample were employed in 31284 of those months.

Table 1 presents summary statistics for our sample. Individuals in our sample are employed in 36 percent of post-injury months. Control variables include standard demographic measures, time-of-accident earnings (for the reasons discussed earlier in this section), part-of-body impairment indicators, and education. The average age in our sample is just over 40 years. Average time-of-accident monthly earnings are just over $2200. Cases of back injury were by far the most common impairment type, comprising 58 percent of the individuals in our sample. Individuals in our sample were less educated on average than the population as a whole; 30 percent had only primary school, while 40 percent had only some high school.

[5]Despite their vintage, data from this Survey continue to be used because of their uniquely rich detail regarding post-injury labour market experiences. For a recent example, see Campolieti (2004).

[6]Reemployment and accommodation requirements are in section 54 of the Ontario Workers' Compensation Act, as amended in 1989 by Bill 162.

[7]For a more detailed discussion, see Cater (2000).

# 4 Results

The estimation results for the model described in equations (2), (3), and (4) are presented in Table 2.[8] The coefficients on the age and marital status variables are significant and have the typical signs. Neither the income nor the unemployment rate variables have a statistically significant effect on the probability of employment.

Any ways in which education serves to mitigate the disabling effects of our four part-of-body categories are embedded in the many individual and interactive terms that involve the education controls. This, of course, makes it difficult to gauge those effects from Table 2 directly. So, to facilitate interpretation, Figure 1 presents simulated employment probabilities from our model for the first 36 post-injury months, by impairment type and education level, for a hypothetical married man, with the mean values of age and time-of-accident earnings and facing the mean unemployment rate. The unobserved individual component is set to its mean value of 0.

In examining the four frames of Figure 1, clear differences in the employment probabilities and in the effects of education on those probabilities are apparent. In the case of wrist/finger impairments, those with a high school diploma or more are, by roughly the two year post-injury mark, employed with a probability of 93 percent  a rate of employment roughly equal to the rate of employment in population as a whole, other things being equal.6 Those with permanent wrist/finger injuries within the two less-well-educated categories have lower employment probabilities, as one would expect. But the gap of about 15 percentage points between the employment rates for the two less well educated groups and the most educated group is greater than the gap within the population as a whole, other things being equal.[9] These patterns suggest that although the work-disabling impact of a permanent wrist/finger on the less well educated is small, there is little, if any, disability realized by those who have a higher level of education. This may simply reflect the fact that the most educated group has access to occupations in which dexterity is not a key determinant of productivity.

For permanent knee injuries, the employment probability for those with only a primary education is roughly 40 percent by the 2-year post-injury mark, dramatically lower than the work probability in the population, other things being equal. By contrast, the employment rates for those in the two more educated categories are roughly 40 percentage points higher than that, and much closer to the employment rates in the population. These results indicate both to a potentially serious work-disabling effect and to a strong disability-mitigating effect of education for this injury type, pointing to a potentially important role for education in mitigating the realized work-disabling effects of reduced mobility.

In the case of shoulder injuries, we see a particularly wide spread of employment rates across education categories. An employment probability of less than 20 percent at the three-year post-injury mark suggests that shoulder injuries are highly work-disabling within the context of jobs available to those with only a primary school education. Higher levels of education have very dramatic effects on the value of employment for those within this impairment category, but even those in the “some high school” category realize a significant work disability. It may be that only the “high school or more” category have access to jobs in which, say, no lifting is involved.

With permanent back injuries, the employment probabilities increase with the level education;

[8] A positive (negative) coefficient points to a positive (negative) relationship between the value of the associated variable and the value and probability of employment. Tests of the joint effects of each of the IxT, IxE, TxE, and IxTxE parameter sets individually are each significant at the 5 percent level. A single test of the joint effect of all of the parameters sets combined is also significant at the 5 percent level.

[9] Data from the 1991 Canadian Census show employment probabilities for comparable Ontario men with grade school, some high school, and high school or more were roughly .82, .87, and .92, respectively.

those with a high school diploma or more have an employment probability of 37 percent at the two year post-injury mark, roughly three times that for the least-educated category. From this, we can infer that the disability-mitigating effects of education are significant in a proportionate sense. But the relatively low employment probability for even the most educated workers in our sample suggests that back injuries are much more broadly work-disabling than our other impairment categories, effectively transcending occupations, and that the capacity for education to circumvent those disabling effects is therefore far from complete.

## 5 Post-Injury Occupational Choice

Our theoretical framework makes three comparative static predictions. First, individual characteristics and impairment types that increase (decrease) the 'value' of the 'best' employment option will increase (decrease) the probability of post-injury employment, other things equal. Second, individual characteristics and impairment types that increase (decrease) the 'value' of a different occupation, relative to the pre-injury occupation, will increase (decrease) the probability that the individual will shift to that different occupation, post-inury, other things equal. Third, and similarly, individual characteristics and impairment types that increase (decrease) the 'value' of the pre-injury occupation, relative to other occupations, will increase (decrease) the probability that the individual will hold post-injury employment in the pre-injury occupation, other things equal.

The results of the previous section relate to the first of these predictions, bearing out our hypothesis that the impact of education on the probability of employment is greater for permanently impaired workers than it is for the overall population. That section's focus on the probability of employment alone, however, does not allow us to explore the rich and important implications of our second and third comparative static predictions.

To remedy this, we now consider a subsample of the sample described in Section 3, for which information on the pre- and post-injury occupation(s) was available. This subsample is comprised of 1632 individuals who were observed for 54189 post-injury months and employed in 19250 of those months. Mean individual characteristics are statistically indistinguishable from those in the our full sample.

Conditioning on the injury type, the pre-injury occupation and the level of education, Tables 3 through 6 show the probability of post-injury employment in each of seven occupational categories in any given month. For example, Table 3 shows us that individuals who experienced a back injury, whose pre-injury occupation was "white collar", and who had an education level of "high school" (or more) had a 32 percent probability of being employed in a "white collar" occupation, a 1 percent probability of being employed in a "sales and service" occupation, a 0 percent probability of being in a "farming, forestry and mining" occupation, and so on, during any observed post-injury month.

These results allow us to address a number of questions. First, does education facilitate adaptation through occupational shifting or through functional adaptation within the context of the pre-injury occupation? The results in Tables 3 through 6 show that job shifting is no more common in the more- than it is in the less-educated groups – indeed, there is little or no evidence of job shifting for any education level. The higher rates of post-iniury employment experienced by those who are more educated thus result almost entirely from their higher rates of resumption of the pre-injury occupation.

Second, is the nature of the pre-injury occupation an important factor in determining post-injury employment probabilities? Although the number of independent observations in each injury-type / pre-injury-occupation / level-of-education cell is insufficient to infer patterns in the population, the patterns in our sample suggest that the answer to this question may be "yes". For example, back injuries result in similarly low rates of return to each occupational category, which is generally consistent with a back injury's potential limitations on lifting, carrying, bending, walking, sitting or standing for prolonged periods. Not surprisingly, wrist and finger injuries, although generally not as disabling as the other injury types, do seem to be particularly limiting in those occupations that require repetitive motions of the wrist and fingers, including equipment operating and material handling. Shoulder injuries appear to be most generally disabling within the context of construction occupations, which involve the sorts of lifting and reaching that shoulder impairments tend to limit, while knee injuries seem to be most limiting within the context of sales and service as well as construction occupations, which involve standing and walking.

Third, is experience in the pre-injury occupation an important factors in determining one's post-injury employment status? In light of our results, this question is particularly important. As noted above, when a particular impairment type is more disabling in, say, occupation $A$ than it is in occupation $B$, our theoretical framework points to the possibility of movement from occupation $A$, pre-injury, to occupation $B$, post-injury, while those who had been in $B$ should tend to return to that same occupation. What we essentially observe, however, is that those who were in $B$ tend to return to $B$, and that those who were in $A$ tend to return to A, albeit at a lower overall rate. This suggests that the extent of realized disability resulting from a given impairment is not strictly a function of the nature of the work being performed. Occupation-specific human capital plays a key role in in enabling an impaired worker to meet that occupation's requirements.

Finally, what do our results imply about why education mitigates disability and why its mitigating effects may differ across impairment types? Because occupation-specific human capital plays an important role, one possibility is that education mitigates the disabling effects of physical limitations because it facilitates the accumulation of that capital. This, in turn, may either allow the individual to better understand alternative/adapted approaches to a task or it may simply result in increased productivity that acts as a sort of buffer against productivity loss. This suggests that the differing disability-mitigating effects of education across impairment types that were identified in Section 4 reflect differences in the extents to which experience and knowledge can compensate for particular physical losses.

# 6 Concluding Remarks

To any workers' compensation system concerned with the mitigation of the welfare impact of occupational injury, the provision of income replacement is, in part, problematic, for benefit payments have the potential to undermine work incentives. Indeed, this concern has been a major impetus behind the development of legislated workplace accommodation requirements intended to mitigate the welfare impact of physical impairments not by compensating for the lost opportunities to work, but rather by altering the work or workplace to facilitate employment.

What we have considered here is the question of whether, and to what extent, education similarly facilitates post-injury employment, not by altering the nature of a particular job or its environment, but rather by, in essence, enabling the individual to better adapt to the requirements of a particular set of tasks or work environment, or to shift to jobs that are, in the face of a particular physical limitation, simply easier to perform. Studying post-injury employment rates and occupational choices as sources of inference into disability, our results point to a potential role for both education and the accumulation of experience as parts of an effective post-injury disability-mitigating strategy.

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Table 1: Summary Statistics

| | | Mean | Std. Dev. | Description |
|---|---|---|---|---|
| Dependent variable | | .36 | | if employed |
| Independent Variables: | | | | |
| Non-time-varying: | age | 40.55 | 12.06 | Age at time of accident |
| | married | .80 | | 1 if married male |
| | ln(time-of-accident earnings) | 7.71 | .35 | Earnings/month (1986$) |
| | Impairment: (excluded=back) | | | |
| | wrist/finger | .22 | | 1 if wrist/finger |
| | shoulder | .10 | | 1 if shoulder |
| | knee | .10 | | 1 if knee |
| | Education:(excluded=some high school) | | | |
| | primary school | .30 | | 1 if less primary school |
| | high school or more | .30 | | 1 if high school or more |
| Time-varying: | Unemployment rate | 8.70 | 1.39 | Unemployment rate (%) |

Table 2: ML Estimates of Model Parameters

| | Variable | Coefficient | Std. Error |
|---|---|---|---|
| $X$ : | age | .097 | .020* |
| | age$^2$ | -.001 | .000* |
| | married male | .311 | .090* |
| | ln(time-of-accident earnings) | .038 | .098 |
| | unemployment rate | -.000 | .007 |
| $I$ : | hand | .600 | .143* |
| | shoulder | .555 | .198* |
| | knee | .675 | .190* |
| $T$ : | $T$ | .059 | .004* |
| | $T^2$ | -.126 | .010* |
| | $T^3$ | .062 | .007* |
| $E$ : | primary | -.219 | .118*** |
| | high school or more | -.052 | .119 |
| $I \times T$ : | wrist/fingers$\times$ $T$ | .064 | .008* |
| | wrist/fingers$\times$ $T^2$ | -.115 | .023* |
| | wrist/fingers$\times$ $T^3$ | .048 | .017* |
| | shoulder$\times$ $T$ | .003 | .010 |
| | shoulder$\times$ $T^2$ | .005 | .032 |
| | shoulder$\times$ $\mathrm{T}^3$ | -.023 | .026 |
| | knee$\times$ $T$ | .072 | .009* |
| | knee$\times$ $T^2$ | -.185 | .024* |
| | knee$\times$ $T^3$ | .113 | .016* |
| $I \times E$ : | wrist/finger$\times$ primary | .190 | .239 |
| | wrist/finger$\times$ high school or more | -.183 | .211 |
| | shoulder$\times$ primary | .074 | .290 |
| | shoulder$\times$ high school or more | .447 | .311 |
| | knee$\times$ primary | -.519 | .305*** |
| | knee$\times$ high school or more | -.066 | .297 |
| $T \times E$ : | $T\times$ primary | -.019 | .006* |
| | $T^2\times$ primary | .047 | .015* |
| | $T^3\times$ primary | -.026 | .010** |
| | $T\times$ high school or more | .042 | .006* |
| | $T^2\times$ high school or more | -.116 | .016* |
| | $T^3\times$ high school or more | .088 | .012* |
| $I \times T \times E$ : | wrist/finger$\times$ $T\times$ primary | .040 | .014* |
| | wrist/finger$\times$ $T^2\times$ primary | -.144 | .040* |
| | wrist/finger$\times$ $T^3\times$ primary | .097 | .030* |
| | wrist/finger$\times$ $T\times$ high school or more | .018 | .012 |
| | wrist/finger$\times$ $T^2\times$ high school or more | -.059 | .036 |
| | wrist/finger$\times$ $T^3\times$ high school or more | .049 | .028 |
| | shoulder$\times$ $T\times$ primary | -.002 | .017 |
| | shoulder$\times$ $T^2\times$ primary | -.050 | .056 |
| | shoulder$\times$ $T^3\times$ primary | .052 | .048 |
| | shoulder$\times$ $T\times$ high school or more | -.063 | .020* |
| | shoulder$\times$ $T^2\times$ high school or more | .208 | .070* |
| | shoulder$\times$ $T^3\times$ high school or more | -.168 | .068** |
| | knee$\times$ $T\times$ primary | -.005 | .015 |
| | knee$\times$ $T^2\times$ primary | .018 | .043 |
| | knee$\times$ $T^3\times$ primary | -.024 | .032 |
| | knee$\times$ $T\times$ high school or more | -.053 | .016* |
| | knee$\times$ $T^2\times$ high school or more | .162 | .046* |
| | knee$\times$ $T^3\times$ high school or more | -.116 | .037* |
| | Constant | -3.798 | .774* |
| | ln $\sigma_\alpha^2$ | .943 | .038* |

n=85832. *, **, and *** denote significance at the 1, 5, and 10 percent levels.

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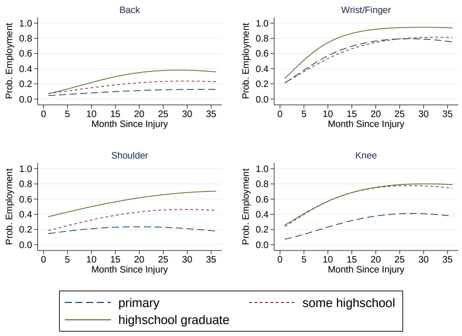


Figure 1: Simulated Post-Injury Employment Probabilities

Table 3: Distribution of Post-Injury Occupations — Back

| | | | Post-Injury Occupation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Education | I | II | III | IV | V | VI | VII |
| Pre-Injury Occupation | I: White collar | High school | 0.32 | 0.01 | 0.00 | 0.03 | 0.00 | 0.00 | 0.01 |
| | | Some high school | 0.22 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | Primary | 0.24 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| | II: Sales and service | ” | 0.03 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.16 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| | III: Farming, forestry and mining | ” | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.00 | 0.22 | 0.00 | 0.01 | 0.04 | 0.02 |
| | | | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 |
| | IV: Processing, machining and fabricating | ” | 0.02 | 0.02 | 0.00 | 0.23 | 0.00 | 0.00 | 0.01 |
| | | | 0.01 | 0.02 | 0.00 | 0.23 | 0.01 | 0.01 | 0.01 |
| | | | 0.00 | 0.04 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 |
| | V: Construction | ” | 0.00 | 0.04 | 0.00 | 0.01 | 0.30 | 0.01 | 0.00 |
| | | | 0.00 | 0.00 | 0.01 | 0.01 | 0.18 | 0.01 | 0.00 |
| | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 |
| | VI: Equipment operating and material handing | ” | 0.01 | 0.07 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 |
| | | | 0.00 | 0.04 | 0.00 | 0.01 | 0.01 | 0.21 | 0.01 |
| | | | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 |
| | VII: Other | ” | 0.04 | 0.02 | 0.00 | 0.03 | 0.00 | 0.00 | 0.30 |
| | | | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.11 |
| | | | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 |

Table 4: Distribution of Post-Injury Occupations — Wrist/Finger

| Pre-Injury Occupation | | Post-Injury Occupation | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Education | I | II | III | IV | V | VI | VII |
| I: White collar | High school | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Some high school | 0.55 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Primary | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| II: Sales and service | ” | 0.00 | 0.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| III: Farming, forestry and mining | ” | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.00 | 0.50 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.01 | 0.54 | 0.00 | 0.00 | 0.00 | 0.00 |
| IV: Processing, machining and fabricating | ” | 0.01 | 0.03 | 0.00 | 0.55 | 0.00 | 0.02 | 0.03 |
| | | 0.01 | 0.01 | 0.00 | 0.40 | 0.00 | 0.01 | 0.00 |
| | | 0.01 | 0.01 | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 |
| V: Construction | ” | 0.00 | 0.03 | 0.00 | 0.00 | 0.60 | 0.00 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.02 | 0.48 | 0.00 | 0.00 |
| | | 0.00 | 0.01 | 0.00 | 0.00 | 0.37 | 0.00 | 0.00 |
| VI: Equipment operating and material handing | ” | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.41 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 |
| | | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.54 | 0.00 |
| VII: Other | ” | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.63 |
| | | 0.00 | 0.04 | 0.00 | 0.00 | 0.02 | 0.00 | 0.33 |
| | | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.45 |

Table 5: Distribution of Post-Injury Occupations — Shoulder

| | | | Post-Injury Occupation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Education | I | II | III | IV | V | VI | VII |
| Pre-Injury Occupation | I: White collar | High school | 0.37 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | Some high school | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| | | Primary | . | . | . | . | . | . | . |
| | II: Sales and service | ” | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.18 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | III: Farming, forestry and mining | ” | . | . | . | . | . | . | . |
| | | | 0.00 | 0.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| | IV: Processing, machining and fabricating | ” | 0.02 | 0.05 | 0.00 | 0.36 | 0.01 | 0.05 | 0.00 |
| | | | 0.01 | 0.01 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 |
| | | | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.01 | 0.00 |
| | V: Construction | ” | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.00 |
| | | | 0.02 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.00 |
| | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |
| | VI: Equipment operating and material handing | ” | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 |
| | | | 0.02 | 0.00 | 0.00 | 0.01 | 0.01 | 0.28 | 0.00 |
| | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 |
| | VII: Other | ” | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 |
| | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| | | | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |

A “.” denotes no observations in the pre-injury occupation and education category.

Table 6: Distribution of Post-Injury Occupations — Knee

| Pre-Injury Occupation | Education | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|
| | | Post-Injury Occupation | | | | | | |
| I: White collar | High school | 0.73 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 |
| | Some high school | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Primary | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| II: Sales and service | ” | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.02 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | . | . | . | . | . | . | . |
| III: Farming, forestry and mining | ” | 0.06 | 0.00 | 0.03 | 0.57 | 0.00 | 0.08 | 0.00 |
| | | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 |
| IV: Processing, machining and fabricating | ” | 0.00 | 0.00 | 0.00 | 0.58 | 0.00 | 0.00 | 0.01 |
| | | 0.00 | 0.00 | 0.00 | 0.64 | 0.00 | 0.00 | 0.00 |
| | | 0.00 | 0.01 | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 |
| V: Construction | ” | 0.00 | 0.00 | 0.06 | 0.00 | 0.47 | 0.00 | 0.00 |
| | | 0.00 | 0.01 | 0.00 | 0.00 | 0.20 | 0.06 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.03 |
| VI: Equipment operating and material handing | ” | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.44 | 0.00 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 |
| VII: Other | ” | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 |
| | | 0.00 | 0.02 | 0.00 | 0.00 | 0.06 | 0.00 | 0.33 |
| | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 |

A “.” denotes no observations in the pre-injury occupation and education category.