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Life-expectancy estimations and the determinants of survival after 15 years of follow-up for 81 249 workers with permanent occupational disabilities

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Objectives This study attempts to estimate life expectancy and explore the determinants of survival for workers with permanent occupational disabilities.

Methods A database on permanent occupational disabilities occurring between 1986 and 2000 was linked with the national death registry database to construct the survival function. A method with Monte Carlo simulation was used to extrapolate survival for up to 600 months to derive the life expectancy for different disability grades (N=81 249). A Cox (proportional hazard) regression was carried out to explore the determinants and to estimate the hazard ratios. Demographic variables, including age, gender, insured wage, severity of disability, injury causes, and organ-system disability, were included in the model as covariates.

Results The results indicate that the survival period for workers suffering permanent occupational disabilities is shorter than that of the general population, amounting to an estimated loss of life expectancy ranging from 5 to 19 years. After adjustment for age and gender, a higher severity of disability, impairment of vital organs or lower extremities, and a lower insured wage had a significant association with shorter survival. Injury types, including transportation incidents, being struck by sliding objects, or a trip, slip or stumble, and collapse injury, indicated hazard ratios of between 1.24 and 1.34, as compared with injuries such as being trapped or caught in machinery.

Conclusions The findings identify major determinants for predicting survival for workers with permanent occupational disabilities; these determinants may be of use in improving the equity of the compensation system for workers.

Key terms Cox model; life expectancy lost; lifelong extrapolation; Monte Carlo simulation; survival analysis; traumatic occupational injury.

Permanent disabilities resulting from traumatic occupational injuries pose significant problems for employees, employers, and society (1–3). There are many studies that deal with the issue of productivity loss measurement (4, 5). There is, however, a need to determine the impact on a person's physical functionality (6) and life expectancy or years of potential life lost after a serious injury (7). Previous studies seemed to focus on specific groups of persons, mainly those involving traumatic brain injuries or injuries to the spinal cord or lower back (8–13), and tried to identify predictors of temporary disability duration (14). Thus there is still a general lack of studies examining survival and its determinants for workers with permanent occupational disabilities.

Recent labor statistics from Taiwan have shown that there were over 5000 claims each year for permanent disability compensation during 2001–2003 (15); however, the current compensation system in Taiwan allows for the payment of only lump sum amounts of up to 60 months of the insured salaries to the victims. While the government is currently planning to change this system to a monthly payment system for the most serious injuries, such as quadriplegia, the lack of information on survival and the uncertainty of the financial burden hinder the decision-making ability of the officials involved. Moreover, in the absence of any means of estimating life-expectancy loss, such costs are currently being sustained totally by the disabled, and the true costs

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derived from such occupational injuries may therefore remain underestimated.

The main objectives of this study were therefore to estimate life expectancy in cases in which people have sustained permanent occupational disabilities and to explore the determinants of survival for the persons who have sustained such injuries. Two authors of this study jointly developed a Monte Carlo approach to extrapolate survival for follow-up studies (16); this method has been corroborated to possess good validity for extrapolation to survivors of serious diseases, such as acute myelogenous leukemia (17). The finding of this study should prove useful in quantifying the actual life-expectancy loss, in years, from such occupational injuries and in refining a future system in Taiwan, for a more appropriate compensation for disabled workers.

Study population and methods

Study population

The labor insurance scheme in Taiwan has been administered by the Bureau of Labor Insurance since 1950; and, in 1981, the system began covering all companies and firms with more than 10 employees. For an occupational injury resulting in permanent disability, the Bureau of Labor Insurance offers the insured person a lump-sum payment based on both the severity of the permanent disability and the insured worker's monthly wage.

According to the Bureau's database, between 1986 and 2000, there was a total of 84 436 compensation claims for permanent disability resulting from work-related injuries. Of these, 3187 claims of migrant workers from other countries were excluded from our analysis on the basis of the lack of survival information in Taiwan. Our study therefore takes a total of 81 249 (96.2%) claims for permanent disability as its sample. All of them provide the following information: the victim's identification (ID) number, date of birth, insured wage, injury type, severity of disability, and affected organs.

Disability and injury characteristics

The severity of the disability, or the physiological dysfunction of the persons, was initially documented by physicians and later categorized into 15 grades by the Bureau of Labor Insurance. Cases with the most serious levels of disability (grade 1) were compensated with a lump-sum payment equal to 1800 day's wages, while those with the mildest disabilities (grade 15) were compensated with a lump-sum payment equal to 45 day's wages.

Given the relatively small difference between adjacent grades, we reclassified the 15 grades into the fol-

lowing five levels for this study: (i) most serious, (ii) serious, (iii) moderate, (iv) mild, and (v) mildest. However, such levels could be further categorized in terms of the percentage of a person's work incapacity (18). The people in the "most serious" disability category were certified by medical assessment as totally incapable of working or possessing 100% work incapacity. In line with this assessment, the work incapacity for each of the respective groups was accordingly categorized as 100%, 64–88%, 33–52%, 12–26%, and 4–7%.

The Bureau of Labor Insurance categorizes causes of injury into 20 different types in its computerized registry database. With the exception of the 10 leading causes of injury, the remaining causes were brought together as a "not elsewhere classified" (NEC) group, which accounted for fewer than 300 cases during 1986–2000. There was also a total of 6411 cases with blank, erroneous, or unclassified causes of injury, which were categorized as "not otherwise specified" (NOS).

The Bureau of Labor Insurance further classifies all of the organ-system disabilities documented within the medical certificates according to the following nine items: (i) the central nervous system; (ii) the organs in the chest or abdominal cavity, including transplants; (iii) deformed trunk; (iv) vision (eyes); (v) hearing (ears); (vi) mouth or teeth; (vii) skull or facial appearance; (viii) upper limbs (including fingers and palms); and (ix) lower limbs (including toes and soles). There was a total of 3316 cases with blank or unclassified codes for the items, which were categorized as "NOS".

Characteristics of the participants

About 80% (64 591) of the participants were male. The average age of the participants was 38.5 (SD 12.4) years, and their average monthly income was 15 000 (SD 9000) New Taiwan dollars (NTD); the approximate exchange rate in 1996 was USD1.0 = NTD 27.5. About three quarters (76.8%) of the participants suffered from the "mild" or "mildest" disabilities, of which organ-system disabilities were mainly in the upper body extremities and were caused mainly by "trapped or caught in machinery" injuries (68.1%), as shown in table 1.

Survival analysis

The survival of every case of permanent occupational disability was ascertained through linkage with the National Death Registry database from the onset of the participant's injury until December 2000 (19). The Department of Health in Taiwan established a computerized death registry from death certificates verified with the Bureau of Internal Revenue Services at the Ministry of the Interior. If a worker's ID number was not found in the death registry database, then that person

was considered to be alive or censored up to December 2000.

To estimate the survival rates of the participants in different severity grades, a nonparametric estimator known as the Kaplan-Meier (K-M) estimate, which is defined as the sample proportion of observed persons alive at the end of the period of follow-up (20), was calculated by the PROC LIFETEST procedure with SAS software (21). Cox's regression model, which does not require assuming a particular probability distribution for the survival time of each category of participants, was conducted to explore what determinants affected the participants' survival (22). The following variables were included as the covariates: age, gender, insured wage, severity of the disability, cause of injury (types), and organ-system disability. Given the lack of information on the general population, we assumed that the mildest disability, disability of skull or facial appearance, and "trapped or caught in machinery" injuries were the reference baselines for the model construction. All of the Cox's regression analyses were performed by the PROC PHREG procedure with SAS software 8.02 edition (23).

Monte Carlo method and estimation of loss of life expectancy

A Monte Carlo simulation method was designed to project the survival times beyond the follow-up limit of 180 months (16, 24). Briefly, the major idea of the method is to borrow information from a reference population, of which the survival function is obtained from the life table of the general population of Taiwan. The extrapolation process comprised three phases. First, for each participant with a permanent disability, we chose a reference person of the same age and gender with a known hazard function in the vital statistics or the life table of the general population. The survival time of the referent was then generated according to the Monte Carlo method on the basis of the hazard functions of the matched onset age and gender. Second, the hazard function for the participants with a permanent disability is assumed to be proportional to that of the reference population at each time t . Therefore, the ratio $W(t)$ exists between survivals of both the participant with a permanent disability and the referent. The logit transform of the ratio $W(t)$ will become linear after a period of follow-up, usually after intensive medical intervention and therapeutic rehabilitation have been completed. Then the logit transform was fitted by a simple linear regression from time zero up to the end of the follow-up period. Finally, the estimated regression line and the survival curve of the reference population were used to extrapolate long-term survival beyond the follow-up limit (16).

The standard error of the survival estimate could be obtained by using resampling techniques through the

Table 1. Frequency distributions of the severity of disability, organ-system disability, and injury type among the people included as cases in the study (N=81 249).

Variables	N	%
Disability severity (dummies)		
Most serious	2 334	2.9
Serious	2 326	2.9
Moderate	13 320	16.4
Mild	37 168	45.7
Mildest	23 128	28.5
Not otherwise specified	2 973	3.6
Organ-system disability (dummies)		
Nervous or psychological disorders	2 643	3.3
Trunk	1 052	1.3
Chest or abdomen	707	0.9
Eye	2 757	3.4
Facial appearance	1 426	1.8
Mouth or teeth	595	0.7
Ear	264	0.3
Lower extremities	6 182	7.6
Upper extremities	62 339	76.8
Not otherwise specified	3 284	3.9
Injury type (dummies)		
Trapped or caught in machinery	55 301	68.1
Cut, laceration, puncture	5 421	6.7
Transportation incidents	4 892	6.0
Struck by sliding or slipping object	1 667	2.1
Fall to lower level	1 567	1.9
Slip, trip or stumble	1 098	1.4
Collapse or tumble down	1 251	1.5
Struck by flying or falling object	1 204	1.5
Electric accident	411	0.5
Crash or dash	329	0.4
Not elsewhere classified	1 615	2.0
Not otherwise specified	6 493	7.9

bootstrap method (25). Each group of participants with the same severity grade is sampled with replacement from the original data set. We repeated the bootstrap procedure 30 times to collect a sample of 30 bootstrap estimates of mean survival times. The standard error of the mean survivals is therefore given by the sample standard deviation of the bootstrap estimates. The statistical package, MC-QAS written in R&S-Plus software (26), was used for the preceding computation, which can be downloaded from the following website: <http://www.stat.sinica.edu.tw/jshwang/qas.htm>.

Using 1995 vital statistics on Taiwan and survival data for each severity grade as the variables, the program estimated the mean survival times for the case and reference populations for up to 600 months. The mean survival difference between the two represented the life-expectancy loss, in months, for the different grades of severity of injury. In order to test the validity of the Monte Carlo method, we extrapolated the injury cases from 1986 to 1995 (with 120 months of follow-up) to 180 months on the basis of the Monte Carlo extrapolation and the parametric model approach under the Weibull distribution using the S-Plus software, comparing the outcomes with the K-M estimates of the actual

follow-up to 2000 or the end of the 180-month follow-up period.

Results

Life-expectancy estimations and potential years of life lost

Table 2 summarizes the distribution of the case numbers and deaths during the follow-up period among the participants with different grades of permanent disability. Because the observation on the participant's survival was terminated by December 2000, most of the disabled remained alive and were regarded as censored (21). The censored rate indicated the percentage of disabled still alive at the end of the follow-up in the different severity grades. In the study, the disabled with grade 1 severity showed the lowest censored rate, with the value of 63.6%. The K-M estimates were generally higher for the less severe grades and consistent with the grades of severity of disability as defined by the Bureau of Labor Insurance. The survival times during the 180-month follow-up period indicated a similar trend.

The cohorts established between 1986 and 1995 (120 months) were extrapolated to an additional 5 years and were then compared with actual survival following 180 months of follow-up, from 1986 to 2000 (table 2). The range of the survival differences was generally less than 3 months, with the exception of the grade 4 persons, among whom there were only seven deaths out of 100 cases or a small sample size. Otherwise, when compared with the results of the actual follow-up or K-M estimates, the Monte Carlo method was relatively accurate.

The expected mean survival months for the participants with different grades of disability were estimated by the Monte Carlo method using 180 months of follow-up, subsequently extrapolated to 600 months. In comparison with the general population, with the exception of the estimates of the participants with grade 4 severity, the estimates of lost life expectancy among the participants with all of the other grades varied between 228.6 months and 95.6 months.

Determinants of survival for workers with permanent occupational disability

The hazard function of the variable as the reference baseline is assumed as a unit. Therefore, the hazard

Table 2. Frequency distributions and survival estimates for different levels of severity for compensation after 180 months of follow-up—Kaplan-Meier estimates and survival times were compared with those calculated by the Monte-Carlo (MC) method and the Weibull distribution extrapolated from 120 to 180 months. Extrapolation to lifelong survival and life-expectancy lost was based on the MC method from 180 months extrapolated to 600 months. (SEM = standard error of the mean)

Level of severity	Cases (N)	Death (N)	Censored rate (%)	Kaplan-Meier estimate	Survival up to 180 months	MC method from 120 to 180 months		Weibull model from 120 to 180 months	Lifetime survival based on MC method		Life expectancy lost based on MC method	
						Mean	SEM		Mean	SEM	Mean	SEM
Most serious												
Grade 1	700	255	63.6	0.437	115.3	115.9	5.7	115.9	158.3	11.3	228.6	11.2
Grade 2	1 166	158	86.4	0.675	147.7	146.4	4.7	146.1	225.8	19.9	162.2	19.7
Grade 3	468	49	89.5	0.621	148.9	147.1	8.9	146.5	209.9	21.9	168.0	22.5
Serious												
Grade 4	100	7	93.0	0.902	169.5	144.7	19.4	160.5	362.9	33.7	60.0	3.9
Grade 5	798	57	92.9	0.841	166.6	165.7	3.0	166.3	309.2	28.1	116.2	28.4
Grade 6	1 428	109	92.4	0.840	166.6	169.5	2.2	170.3	281.7	16.8	143.1	17.1
Moderate												
Grade 7	3 047	248	91.9	0.804	163.9	161.8	1.8	163.9	258.1	8.7	126.9	8.4
Grade 8	4 755	236	95.0	0.872	169.2	169.8	1.2	171.7	308.9	14.4	134.5	14.5
Grade 9	5 518	240	95.7	0.904	170.8	170.8	1.2	172.2	327.7	11.5	121.7	11.7
Mild												
Grade 10	5 942	258	95.7	0.895	171.1	172.0	1.0	172.6	332.2	11.6	118.7	11.8
Grade 11	12 865	676	94.7	0.883	170.5	171.2	0.6	172.5	318.4	7.5	128.7	7.1
Grade 12	18 361	728	96.0	0.925	172.6	173.6	0.6	174.7	358.9	7.5	108.0	7.3
Mildest												
Grade 13	11 981	496	95.9	0.912	172.2	172.0	0.9	173.9	340.5	11.1	117.3	11.4
Grade 14	5 402	216	96.0	0.921	172.1	172.7	0.8	173.7	369.1	15.7	95.6	16.1
Grade 15	5 745	230	96.0	0.904	172.1	173.0	1.0	174.2	345.3	15.4	103.8	15.1
Not otherwise specified	2 973	192	93.5	0.820	166.0	166.8	1.0	166.3	290.5	17.8	137.9	17.6

ratio could be regarded as the relative risk for mortality among the cases attributed to different categories of variables at the end of the follow-up. Table 3 summarizes the estimates of the hazard ratios and the 95% confidence intervals under different input covariates in the Cox models. The results show that the effects, or hazard ratios, of age, gender, and insured wage were relatively stable, even when different covariates were entered into the Cox models. The hazard ratio was significantly lower for the disabled with a higher insured wage prior to the occurrence of the injury. The severity of disability also affected survival, with the "most serious" group revealing a hazard ratio of 5.74 in a univariate analysis, which was adjusted to 3.13 after control for the covariates of organ-system disability and injury types (table 3).

The models indicated that organ-system disability had an important impact on survival, the magnitude of the hazard ratios ranging from 5.22 to 2.56. A significant contribution was also apparent from different types of injuries, the hazard ratios ranging from 1.24 to 1.34.

Discussion

The compensation systems for workers in most countries, including the system used in the United States (27), do not usually take into account the victim's potential loss of life expectancy. To our knowledge, this study is the first in the world to attempt to quantify life expectancy loss, as well as the determinants of long-term survival, for workers suffering permanent disabilities as a result of an occupational injury.

Our results show wide variations for both the hazard ratio and the survival of people with different injury characteristics (table 3). In addition, the lifelong survival estimations, according to the Monte Carlo method, ranged between 13.2 and 30.8 years for different grades of disability severity. The worker's expected years of life lost was further calculated, showing a reduction ranging from 5 to 19.1 years as compared with the vital statistics for Taiwan with respect to the life expectancy for the general population. Such results indicate that people with a permanent occupational disability generally have a shorter life expectancy after the occurrence of the injury; nevertheless, we must first validate the method used.

Estimation validity based upon the Monte Carlo extrapolation method

The simulation results in table 2 showed that the projected 60 months of survival, based on 120 months of follow-up, were generally accurate for both the Monte

Carlo method and the Weibull model, with the single exception of grade 4 disabilities because of the small sizes of both the cohort and the cases of mortality.

In general, the Weibull model has been one of the most popular parametric methods used to describe the distribution of survival data because of its versatility with two parameters, the scale parameter α and the shape parameter γ (28). In this study, these two parameters were obtained on the basis of the 120 months of follow-up and were fitted for extrapolation to 180 months. Since most of the occupational disabilities in Taiwan resulted from acute injuries, which usually stabilize after 2–3 years, the 60-month extrapolation of the Weibull model appears to be as acceptable as the Monte Carlo method, as shown in table 2. However, the latter also provides an inaccuracy measure.

Implications of the determinants of survival

Although several metrics have been developed to assess the degree of impairment from nonfatal injuries, they do not usually provide any accurate measurement of the

Table 3. Determinants of the hazard ratio for cases with permanent occupational disabilities in different Cox models.

Variables (and definitions)	Cox model 1 ^a		Cox model 2 ^a	
	Hazard ratio	95% CI	Hazard ratio	95% CI
Individual characteristics				
Age (in years)	1.06	1.05–1.06	1.06	1.05–1.06
Gender (male; female)	2.56	2.28–2.86	2.54	2.27–2.84
Wage (x 10 000 NTD)	0.85	0.81–0.89	0.86	0.82–0.91
Disability severity (% work incapacity)				
Mildest (4–7%)	1	Reference	1	Reference
Most serious (100%)	3.20	2.55–4.01	3.13	2.49–3.94
Serious (64–88%)	1.47	1.24–1.74	1.44	1.21–1.71
Moderate (33–52%)	1.16	1.03–1.29	1.15	1.02–1.28
Mild (12–26%)	1.07	0.99–1.16	1.07	0.98–1.16
Organ-system disability				
Facial appearance	1	Reference	1	Reference
Nervous or psychological disorder	5.04	2.20–11.53	5.22	2.28–11.96
Chest or abdomen	4.56	1.92–10.80	4.67	1.97–11.08
Trunk	3.27	1.44–7.43	3.32	1.46–7.54
Lower extremities	3.26	1.46–7.31	3.51	1.56–7.87
Upper extremities	2.49	1.12–5.55	2.95	1.32–6.61
Mouth or teeth	2.94	1.12–7.74	2.97	1.13–7.83
Eye	2.37	1.04–5.39	2.56	1.12–5.84
Ear	2.20	0.81–5.95	2.24	0.83–6.07
Not otherwise specified	2.69	1.11–6.54	2.85	1.17–6.93
Injury type (dummies)				
Trapped or caught in machinery	.	.	1	Reference
Struck by sliding or slipping objects	.	.	1.34	1.11–1.61
Transportation incidents	.	.	1.29	1.10–1.52
Slip, trip or stumble	.	.	1.26	1.03–1.56
Collapse or tumble down	.	.	1.24	1.05–1.47

^a –2 Log likelihood was 83 395.7 for Cox model 1 and 83 368.5 for Cox model 2.

long-term impact on a person (29). Consequently, there is no direct link between disability ratings and a person's ultimate period of survival. On the basis of a 15-year follow-up period and lifetime extrapolation, the Kaplan Meier estimates provided only a poor-to-fair consistency rating along with compensation, as shown in table 2. Thus one needs to explore other risk factors contributing to the reduction in life expectancy among survivors.

After adjustment for age, gender, and insured wage in the Cox model, not only did we find evidence to suggest that the severity of disability has a significant association with the persons' survival, but also that a similar association exists for both organ-system disabilities and causes of injury, as shown in table 3. Disability of life-threatening organs clearly has a higher mortality risk than disability of sensory organs, such as the eyes or mouth; however, people with permanent impairment of the lower extremities were also found to have far worse survival rates than those with impairment of the upper extremities. The reason behind this finding may be attributable to disabilities of the lower extremities usually accompanying impaired mobility and physical inactivity in daily life (9). Our results suggested an association between long-term survival and the degree of physical activity.

There was a general increase in the hazard ratios, of about 5.7%, for each 1-year increase in the person's age at the time that the injury occurred. In addition, there was a general increase in the hazard ratios for the male disabled, of about 2.5 times that of the female disabled. Such a finding is similar to the results of Cheadle et al in 1994, who predicted the duration of temporary total work-related disabilities (30).

In addition, the beneficial lump-sum payment in Taiwan is based on the product of the daily insured wage multiplied by the number of claim days dependent on the grade of disability. Thus the negative effect on survival for the insured wage could have twofold meanings. First, the significant association with a higher insured wage implies that a higher compensation payment would be helpful in prolonging a person's ultimate period of survival. Second, the insured wage may serve as either an instrumental or surrogate variable for household income, a higher income potentially producing an extended period of survival after injury.

Among all of the 12 different causes of injury, we found that four types were significantly associated with the survival of the disabled, with an increase of about 24% to 34% in the hazard ratio, as shown in table 3. Since the injury types and media determine many of the features of hurt or harm, including medication, prognosis, quality of life, and the financial burden after injury (31–33), they may also have an effect on a disabled person's long-term survival.

Study limitations

Although we have used the best data currently available in Taiwan, this study still suffers from a few limitations. First of all, all of the cases were actively employed prior to their injury or were healthy workers (34), who would have longer life expectancies in the absence of work-related disability. As the Monte Carlo simulation used the national vital statistics as the reference population, life-expectancy losses would be underestimated. Second, in the Monte Carlo simulation, we assumed that divergence from the life expectancy of the referents over the interval up to 15 years post-injury would adequately predict departures over the period 15 to 50 years. However, the assumption would be valid only if there were no long-term consequences, such as lost retirement income, social disruption (divorce, loss of friends, etc) that may have a delayed but substantial impact on survival (35) and imply an underestimation of overall impact. Similarly, the mildest disabled cases used as referents in the Cox model would be another potential source for underestimation bias, because they may experience some adverse long-term effect on mortality by way of socialization, employability, or disconsolation. Consequently, we analyzed the standardized mortality ratio for the mildest disabled cases and found that the total mortality was 1.31, or significantly higher than that of the general population. Thus the hazard ratios in table 3 would need an adjustment with approximately the above magnitude if compared with the general population. Third, the constructed Cox model in this study included only the characteristics of injury and demographic factors. We did not include some important covariates, such as the consequences of medical care and rehabilitation, household income, or psychological factors (36), purely because of a lack of information. Therefore, the current estimates of the study represent a major improvement over ignoring life expectancy altogether. It may not be suitable to generalize the results of this study directly to other countries.

Fourth, using the "trapped or caught in machinery" cases as the referents of the covariate of injury type may raise a concern because of diversified consequences. As a result, the hazard ratios in the covariate shown in table 3 was in a range of 1.24–1.34, which implied that the effect of injury types on reducing life expectancy may be mitigated. However, because the mean of life-expectancy losses in this group was found to be the smallest among all injury types, the impact may be limited. Finally, some injury types, such as transportation incidents, may result in multiple organ disabilities and therefore significant elevation of the hazard ratio. Ho et al reported that a person's willingness to pay for the removal of physical pain resulting from occupational injury could also be related to different injury types (37).

Since the computerized files of the Bureau of Labor Insurance only allow a coding of one major organ system, we were unable to determine the detailed mechanisms in terms of increased hazard ratios for different injury types.

Implications of the results

In most of the developed countries, the actual amount provided in permanent disability benefits is usually decided by the degree of disability and loss of income (38). Such a compensation scheme produces earnings-related or premium-related benefits, but, as the degree of disability does not necessarily account for a person's survival, this study argues that, from an equity perspective, it does not take comprehensive account of workers with permanent occupational disabilities, especially those accompanied by premature mortality later on. For example, workers in Taiwan with occupational disabilities of life-threatening systems, such as the nervous system, have invariably been compensated in the same way as cases of injury to the upper extremities due to their equal grading of permanent incapacity.

Our study has provided a new method and direction for decision makers to help them rethink the equity and efficiency of the system of compensation for workers. We recommended that the worker's compensation scheme for permanent disabilities take into account future survival loss and that disabilities to different organ systems, as well as different types of injury, should be considered in accordance with the principles of social justice.

Table 2 showed that the periods of survival for workers with the "most serious" disabilities (namely, permanent total disabilities) were the shortest, while those with "serious", "moderate", or "mild" partial disabilities suffered gradually smaller reductions in survival expectancy. The results imply that compensation for people with the most serious disabilities ought to be considered as the highest priority, and probably with a view to sustainable support, perhaps in the form of a lifelong annuity. In contrast, the people with "moderate", "mild", or "mildest" disabilities, which represent the majority of occupational disabilities, could be compensated by a lump-sum payment and proper rehabilitation back into the employment market.

Finally, this study has shown that injury types represent a significant covariate. Although their significance may not be particularly large, they nevertheless deserve the attention of policymakers to improve the efficient use of limited available resources. In order to minimize the loss of worklife (39), we suggest that the priority of preventive intervention should not only consider occupational mortality, but also serious permanent disability by types of injury.

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