

# Workers' Health in Latin America: An Econometric Analysis of Work-Related Injuries

## **A Health Note**

Antonio Giuffrida  
Roberto F. Iunes  
Héctor Macías

SDS/SOC – Health Note No. 5  
Inter-American Development Bank  
Washington, DC  
December, 2001

*Antonio Giuffrida is an Economist in the Social Development Division of the Sustainable Development Department. Roberto Iunes is a Health Specialist in the Social Programs Division of Regional Department 3. Héctor Macías is a statistician in the Instituto Mexicano del Seguro Social, Mexico DF.*

*The authors express their gratitude for the comments, suggestions and corrections offered by Richard Butler, Sudhanshu Handa, Christian Salas and William Savedoff. The findings, interpretations and conclusions expressed in this paper are entirely those of the authors. They do not represent any official position or analysis attributable to the Inter-American Development Bank, the Instituto Mexicano del Seguro Social, or any individual acting on their behalf.*

*Comments can be sent to Antonio Giuffrida, Inter-American Development Bank, 1300 New York Avenue NW, Mail Stop W-502, Washington, DC 20577, USA. Email ANTONIOGI@iadb.org*

*To obtain access to this and other related publications at the Inter-American Development Bank, visit our website at <http://www.iadb.org>.*

# Abstract

Occupational health is increasingly recognized as an important public health issue in Latin American and the Caribbean. One major concern is the absence of reliable data on its magnitude and economic consequences. The first part of the paper presents the official statistics on workplace injuries, which suggest that workers in the Region are exposed to occupational risks that are significantly higher than in established market economies. In the empirical part of the paper, we analyze health risk associated with occupational hazard in Mexico. This analysis sheds light on the relationships between the likelihood of reporting work-related impairment, characteristics of the workers, type of occupation and contractual relationship.

*Keywords:* Occupational safety and health; Latin America; Workers' compensation

*JEL classification:* J28; I1; O54

# Contents

Introduction	1
Occupational Safety and Health in Latin America	2
Economics Aspects of Occupational Safety	4
Data	6
Estimation Results	9
Conclusion	13

# Introduction

Occupational Safety and Health (OSH) is increasingly recognized by Latin American and Caribbean (LAC) governments and International Organizations as an important part of public health. People spend one-third or more of each day at work, thus OSH conditions are a primary determinant of workers' health. However, OSH concerns extend well beyond the obvious health consequences of work-related illnesses, accidents, and deaths. Addressing OSH issues is a key element in the process of social and economic development, with direct and indirect impacts on such areas as the labor market, labor productivity, household income, poverty, social security systems, international trade, and the environment.

The LAC labor force is one of the fastest growing in the world. In 1980 there were 112 million workers, by 1998 the workforce almost doubled reaching approximately 202 million workers (see IDB, 1982; ILO, 1998). Thus, in the Region, OSH has a direct impact on more than 200 million workers and their families, but the situation is far from adequate. First, there is a general lack of awareness regarding the importance of a safe and healthy working environment. Second, the Region lacks the institutional capacity and the

infrastructures needed to develop and sustain a safe and healthy working environment and the Region's failure to implement or enforce appropriate safety laws translates into lost production, lost wages, medical expenses, disabilities, and deaths. Moreover, data on occupational accidents, illnesses, and deaths tend to underestimate the magnitude of the problem. Finally, the knowledge regarding the factors that affect OSH is very limited.

The aims of this paper are, first, to review and briefly summarize the information available in relation to OSH situation in LAC. Second, to analyze the determinants of workplace impairments using the 1996 Mexican National Survey of Employment and Social Security (Encuesta Nacional de Empleo y Seguridad Social; ENESS). This study represents, to our knowledge, the first empirical analysis of this type in any LAC country.

Section 2 describes the OSH situation in the Region. Section 3 presents some aspects of the economic literature in the area of OSH. Section 4 describes the available data. Section 5 presents the results of the analysis. Section 6 concludes the paper with a discussion.

# Occupational Safety and Health in Latin America

It is difficult to quantify the exact rate of occupational injury and illness. This is mainly due to two factors. First, the underreporting of accidents and illnesses in those firms and sectors that are legally registered and obligated to report such incidents. Second, in LAC countries a large proportion of the economically active population is engaged in activities that are not legally registered and for which few if any statistics are collected. The International Labor Office (ILO, 1998) is the principle source of statistics in this field. ILO collects and publishes occupational accident figures and rates that are based on national registration and notification systems and reliable data are obtained from the majority of LAC countries. However, international comparisons are difficult because of inconsistencies in the registration and notification systems. In most countries, the figures refer only to the number of compensated accidents; whereas in others the data refers to all reported accidents. In the majority of countries, the reporting system only covers insured workers, excluding self-employed agricultural workers, domestic servants, and casual laborers, who are known to have higher than average accident rates. Finally, data may cover accidents and occupational diseases associated with commuting, whereas in some cases do not. However, it is likely that inconsistencies among countries are more evident across registration of nonfatal occupational accidents than of fatal ones.

Table 1 reports the fatality rate for occupational accidents in the LAC countries for which data are available and for some non-regional countries such as Canada, USA, and Finland by way of comparison. Overall, the average rate in Latin America and the Caribbean is 0.135 per 1,000 workers, which is just between the rates experienced by the two biggest countries in the sample:

Brazil and Mexico.<sup>1</sup> However, there is a large variation in fatality rates across the Region, which vary from the absence of fatal accidents reported by Barbados in 1995, to the 0.33 accidents per 1,000 workers recorded in El Salvador in 1998. Table 1 also shows that in the largest countries of the Region such as Mexico and Brazil, the reporting systems monitor only one third of the workforce. In other countries such as Peru, the information available refers to only 7% of the workforce. Looking outside the Region, the occupational fatality rates in Establish Market Economies were significantly lower than the average rate for LAC. In 1997, Canada experienced a fatality rate that was almost half that of LAC, while even lower rates were recorded in Finland and the USA.

There are various reasons for the high level of occupational hazards in the Region relative to developed countries.<sup>2</sup> First, workers in LAC tend to work longer hours. Thus, *ceteris paribus*, they are more exposed to occupational hazards than workers in more developed countries.

Second, the level of occupational risks is higher because of the geography and the natural resource endowments of the Region. For instance, dangerous occupations such as mineral extraction play a large role in the Region's economies due to a significant endowment of primary commodities such as tin, copper, gold. Moreover, some geographical characteristics such as high altitude and tropical climates may exacerbate the risk of certain injuries or contracting particular illnesses in the workplace.

---

<sup>1</sup> Since we have weighted the national rate by the number of workers, the importance of the outliers is reduced.

<sup>2</sup> See Giuffrida et al. (2000) for a detailed survey of OSH conditions in Latin America and the Caribbean.

Third, OSH is a new field in the Region and there are fewer experts available, less safety equipment, less monitoring equipment, fewer inspectors and less enforcement than in developed nations (Delclos et al., 1999). Furthermore, OSH research is under-funded in the Region. Some estimates show that only 5% of research in the world takes place in developing countries (Partanen et al., 1999), which represents a severe imbalance considering the population share and the severity of occupational hazards of developing countries.

Forth, a large portion of the workforce is engaged in the informal sector of the economy, composed of micro-enterprises, domestic services, and self-employed workers. In 1998 around 48% of the economically active population on LAC were employed in the informal sector (see Lora and Marquez, 1998; ILO, 1999). In the formal sector, employment in small enterprises of 6-20 workers represents 25% of the total (ILO, 1999). The occurrence of fixed costs and scale economies in reducing occupational hazards as leads to consider that “generally, the smaller the industry is, the higher the rate of workplace injury and illness” (Loewenson, 1994; p.97). Moreover, monitoring of work conditions is also particularly problematic in the informal sector that, often by definition, operates outside formal legal standards and regulation.

Fifth, labor markets in LAC are characterized by elevated unemployment and underemployment rates and by a general absence of unemployment insurance, social security insurance and income maintenance for the unemployed and for those

working in unregulated sectors of the economy. Therefore, many of the Region’s workers may tolerate hazardous working conditions rather than risk losing their jobs. This makes it more difficult to undertake collective action to improve working conditions, including limiting the ability to mobilize strikes. Unions in LAC have been hampered in their ability to promote safer working conditions. They have faced severe repression under numerous dictators and military governments. In other cases or times, unions have been co-opted to serve political interests that did not necessarily reflect the best interests of the membership and had not been immune to the corruption that exists in all spheres of the political and economic life (see Framkin, 1999; Laurell, 1989). Moreover, unions represent only a minority share of workers: those employed in formal workplaces. For these and other reasons, unions in the Region have not been able to have the same positive impact on improving working conditions, as have their counterparts in higher income countries.

Finally, healthy people may be exposed to some level of occupational hazards without apparent effects because the human body has the capacity to deal with such challenges. However, some people can be more vulnerable because of poor hygiene and sanitation, poverty and illiteracy or because they are malnourished or already chronically ill. For such people, exposure to occupational hazards can heighten the risks of serious illness or death. The workforce in LAC comprises a large number of people who are less healthy and therefore more vulnerable to occupational exposure to toxic chemicals or biological agents.

# Economics Aspects of Occupational Safety

The determinants and consequences of workplace safety have been an important issue in the economic literature since the end of the 1960. Various theoretical and empirical studies have been inspired by the introduction of workplace safety regulations in the US, notably the Coal Mine Health and Safety Act (CMHSA) of 1969, and the Occupational Safety and Health Act (OSHA) of 1970. The theoretical literature mainly focused on the justification of government interventions on the market for workplace safety. Empirical work on workplace accidents have mainly concentrated on the effect of CMHSA and OSHA regulations on the frequency and severity of workplace injuries, the relationship between workers' compensation and job safety, as well as the impact of unionization. However, the empirical evidence for the consequences of government safety regulation is mixed. Whereas Viscusi (1986), McCaffrey (1983) and Lanoie (1992) found no or little impact of government safety regulations, the empirical results of Gray and Jones (1991a, 1991b) and Well (1996) indicated a significant positive influence of OSHA inspections on workplace safety.

The economic literature suggests that occupational safety is related to the presence of workers' compensation for occupational accidents and diseases and the nature of the contractual relationship with the employer. Some authors have argued that in a world of perfect markets and complete information the presence of wage differentials for risky jobs implies that public regulation of occupational safety and worker compensation for occupational accidents are unnecessary. Thaler and Rosen (1976) presented a hedonic model where the labor market is perfectly competitive, workers are risk averse and have perfect information about risks of accidents and are also perfectly mobile between jobs, while

firms differ in terms of certain intrinsic risks of accidents but can influence the probability of accidents through undertaking safety expenditures. Under this assumption, workers' compensation insurance is unnecessary and harmful.

However, in if markets are imperfect or have incomplete information, non-optimal situations can occur. As noted by Rea (1981), there are at least five possible types of imperfect information that may affect this market. First, employers and insurers may not be able to identify workers who are accident-prone. This type of misinformation leads to a problem of adverse selection. One solution (or a partial solution) is to restrict the range of choice the insured is allowed, i.e. to impose compulsory insurance to prevent lower risks individuals or firms opting out.

Second, employees and employers may be incorrect in their estimates of occupational risk and of their influence on the level of risk. Under the assumption that workers underestimate risks, Diamond (1977) and Oi (1974) argued that mandatory insurance and safety regulation are justified because they raise the expected utility of risk adverse workers.

Third, there are serious monitoring constraints. Employers may not be able to monitor whether employees are taking proper precautions. The insurers may be unable to monitor precautions taken by either employers or employees. These two types of misinformation involve a particular type of moral hazard, *ex ante* injury hazard, which refers to the effect of the insurance on the choice of self-protective activities taken by the insured when the insurer cannot observe or enforce these activities. Typically, *ex ante* moral hazard leads to an under-provision of self-protection activities by the insured. In the market place for accidents, this problem is compounded with the possibility of *ex ante* "double

moral hazard” (Lanoie, 1991): a workplace accident not only depends on the precaution level of the worker but also of the firm. Insurers have adopted a number of devices to reduce this problem based on incentive mechanisms that share the cost between the insured and the insurer. For instance, the insured worker may have to pay a fraction of any claim or the insurance premiums paid by the employer may be based on its previous safety record. In general insurance for work-related accidents gives opposite incentives to both parties, at least when the employer is experience-rated by the insurance. It decreases the cost of an accident to the worker, inducing less precaution, while increases the cost of an accident to the firm, inducing more precaution. The result is that *ex ante* double moral hazard does not necessarily lead to an underprovision of precaution by both parties. Whether or not it does depends on the substitutability or complementarity of the precautions levels of the two parties and on the chosen level of insurance and intensity of the experience rating.

The final reason why imperfect information affects the insurance market is that the insurer may not be able to monitor the nature of the injury. This type of misinformation concerns *ex ante casualty hazard* and *ex post duration hazard*. When the insurer is not perfectly informed about the state of the world, an insured worker may take action in order to increase the level of his benefits. For instance, he may be encouraged to simulate injuries or to file a claim that occurs off the job, especially in the case of

hard to diagnose injuries. He may also attempt to obtain a longer period of recovery compensated by the social security by exaggerating the severity of his injury.

The above discussion suggests that, due to partial information concerning the risk of accidents and the presence of a variety of informational asymmetries, workers’ insurance for work-related accidents and diseases generates potential problems of moral hazard and other adverse incentives. Thus, it is important to analyze empirically the impact of workers’ compensation on the frequency and the duration of work-related accidents.

The empirical evidence for the consequences of workers’ compensation benefits is mixed and limited to USA data. Chelius (1982) and Neumann and Nelson (1982) conclude that high compensation benefits result in less serious injuries since employers invest more in safety. Ruser’s (1991; 1993) results, on the other hand, indicate that increased workers’ benefits lead to more lost workdays and more severe accidents at work since employees behave less careful.

Empirical evidence from Latin America is not available. In these countries a large share of the workforce is engaged in the informal sector of the economy, where workers’ compensation is not provided. In the next section of the paper we use data from a recent Mexican survey to estimate the effect of social insurance on occupational accidents and illness.

# Data

The empirical analysis is based on the 1996 Mexican National Survey of Employment and Social Security (Encuesta Nacional de Empleo y Seguridad Social; ENESS). The 1996 edition of the ENESS can be used for our purpose because included a special module on work safety and access to social security. Thus, we can evaluate the determinants of OSH in Mexico as well shed light on some of the issues discussed in the previous sections.

The ENESS is a national survey administrated by the Secretaría del Trabajo y Previsión Social and the Instituto Mexicano del Seguro Social together with the Instituto Nacional de Estadística, Geografía e Informática. In the survey 12,235 households were interviewed. After eliminating observations with missing values for least one of the used variables, a final sample of 14,850 observations remained. The details of the variables used in the analysis are showed in Table 2.

## *Dependent Variable*

In the survey there are different questions that relate to the occurrence of work-related accidents and diseases. The first relevant question refers to whether or not the individual suffered from a work-related impairment. This variable (*Impairment*) is a dichotomous variable taking the value of one if the individual suffers from a work-related impairment and zero otherwise. Thus, it can be analyzed using a probit statistical model. Table 2 shows that the percentage of the individuals in the sample that reported work-related impairment is very small, representing approximately 1% of the sample.

The survey distinguishes between *temporary impairment* and *permanent impairment*. Table 2 shows that permanent impairments are more frequent, representing approximately 61% of all impairments reported. One could proceed mod-

eling these two variables separately and estimating an appropriate model for each kind of impairment. This, however, may be incorrect since the two variables are expected to be closely related, representing competing risks of accidents for an individual. Thus, joint estimation of these equations using a bivariate probit model is desirable, because takes this interdependence into account and increases the efficiency of the estimation.

The questionnaire also asks to report the number of *days out of work* due to work-related impairments. Table 2 shows that on average the 14,850 workers in the sample reported losing 1.35 days out of work. Conversely, workers that suffered work-related impairments lost, on average, 88.6 days of work. Statistical problems may arise, because the event we want to model is a non-negative count event with a skewed distribution and the OLS estimator is inappropriate for this type of data (see Cameron and Trivedi, 1998; Winkelmann 1997).<sup>3</sup> The empirical analysis can be improved by the use of statistical models that recognize that the dependent variable is a non-negative integer count event, such as the Poisson and Negative Binomial (NB) count data models. Moreover, in the data we observe a very large number of zeros, which is a common feature of count data events. An alternative approach is the estimation of Zero-Inflated (ZI) models, which allow for systematic differences in the statistical processes governing observations with zero and observations with one or more counts.

---

<sup>3</sup> For a review of count data models with specific emphasis to applications in health care, see Jones (2000).

### *Explanatory variables*

As explanatory variables we use variables related to workers' characteristics, aspects of the occupation, and features of the contractual relationship.

In relation to workers' characteristics we include the age of the worker (together with its squared term), gender and whether or not the person is *married*. We also construct a series of variables regarding the educational level. The estimated models take as baseline an individual with secondary level education (either complete or incomplete) and include dummy variables indicating whether the person did not receive any formal education (*Education 0*), received primary level education (either complete or incomplete) (*Education 1*), or had a higher degree (*Education sup*).

We constructed a dummy variable indicating whether or not the worker is affiliated to a social *security institute* and therefore has the right to receive compensation in case of occupational accidents or diseases. The estimation of the coefficient on this variable is particularly interesting because tests for the effects of moral hazard and other adverse incentives in the insurance system. However, caution is required in the interpretation because there may be differences in the likelihood of reporting accidents between the two groups of worker. Moreover, it could be argued that the decision of participating in the informal sector of the economy and not having social security protection is jointly determined and the endogenous variable. Thus, we test for simultaneity by re-estimating the probit model using instrumental variables.

The data set provides detailed information on the characteristics of the principal occupation of the respondents. In the regression model, we include the weekly remuneration in the principal occupation (*Remuneration*). To some extent, the inclusion of this variable tests the hypothesis of the hedonic wage model formulated by Thaler and Rosen (1976). If the labor market was perfectly competitive and there was perfect infor-

mation about the risk of accidents, we would expect that the likelihood of work-related impairment were *ceteris paribus* associated with higher wages in order to compensate for occupational hazards.

We also include a series of dummy variables indicating the industry sector to test if there are differences in their occupational hazards. Thus, taking as a baseline the public sector and defense, we used dummy variables to indicate agriculture and farming, manufacturing, mining and electricity, communication and transport, construction and services.

Moreover, using an employee with a permanent written contract for a baseline, we distinguished the cases when the worker had a fixed term written employment contract (*Temporary*) or a verbal employment contract (*Verbal*). We also distinguished the cases when the person interviewed was *self-employed*; working without salary, a co-operative worker or family worker (*No salaried*); and whether the individual is working in a different location than the rest of the family (*Migration*). Economic theory is an uncertain guide when it comes to predicting the impact of these "atypical" contractual arrangements on the level of OSH. If the majority of workers regard these characteristics (e.g. the uncertainty of temporary jobs and self-employment) as disamenities, then in a competitive market there should be an increase in other components of the compensation package relative to that given to permanent workers. This may take the form of increased wages for temporary workers of equal skill. However, it is unlikely that temporary workers will be compensated by being offered a safer environment than that one provided to permanent workers. Foley (1998) argues that higher hazard for atypical workers arises from both the demand and the supply sides of the labor market. On the demand side, temporary workers may place a greater emphasis on wages relative to other elements in the compensation package than permanent workers. In this case the theory would predict that they would forgo some safety in favor of

increased wages. Moreover, temporary workers may regard their tenure at any particular work site to be of such a short duration that they would be less exposed to hazards than their counterparts.

From the supply side, temporary workers are usually viewed as short-term resources and employers would reap less benefit from investments to improve these conditions. Employers are less likely to make significant investments in training temporary workers and to improve their work environment. This reasoning, while rational at the level of each individual workplace, is likely to result in greater exposure to hazard when aggregated over many employment experiences. In general, temporary workers will be considered as being less likely to provide a return on any investment in safety.

Moreover, taking as baseline group employees working in an establishment with between 16 and 50 workers, we included dummy variables to distinguish the cases when the establishment was larger or smaller and whether the individual was a street vendor, or in general a worker without a specific premises (*No premises*). We have discussed in section 2 that the size of the enterprise may be related to OSH. Finally, we include a dummy variable that indicates if the worker has a second occupation (*2 Occupation*). We expect that persons having more than one job are exposed to higher occupational hazards and therefore more likely to report work-related impairments.

## Estimation Results

In the regression analysis, we included all the individuals that were between 16 and 65 years of age and were employed at the time of the surveys. After eliminating all individuals with any missing values for the variables included in the regression model we retained 14,850 observations. The baseline in all of the regressions is a male worker, single, working in the public sector or defense, with secondary education, employed with a written permanent contract, not affiliated with a social security institute, working in an enterprises with 16-50 employees and living with the rest of the household. In all the estimations we adjusted the standard errors for the clustered design of the survey, and we used appropriate weights to control for the differences in the probability of selection in the sample. Thus the results can be considered as representative of the Mexican working population between 16 and 65 years of age.<sup>4</sup>

### *Probit model*

Table 3 reports the estimated coefficients together with the estimated marginal effects from a probit model of whether or not the worker reported a work-related impairments. Even if the estimated pseudo- $R^2$  is relatively low (0.1048), the RESET test suggests that the model does not suffer from miss-specification.

The results suggest that there is a strong inverse “U” shaped relationship between occupational accidents and age. The highest probability of reporting work-related accidents or diseases is among individuals whose age is 50 years. In the

literature, we found some evidence suggesting that the probability of incurring in occupational accidents decreases with age (see Root, 1980). However, the dependent variable used in the analysis includes also occupational diseases, and a positive relationship with age is likely to exist because the probability of developing a disease depends on the exposure to the hazard. Thus, it seems sensible that the combined effect of age on work-related impairment takes the form of an inverse “U” shaped relationship.

Among the other variables included in the regression model, we note that female workers and employees with higher education are less likely to report occupational accident or disability. Thus, after controlling for the type of economic activity and other factors, women and highly educated workers are more likely to be employed in positions that are less exposed to occupational hazards. These results probably reflect the fact that women are over-represented in low risk clerical jobs and that highly educated workers are disproportional employed in low risk occupation such as management.

We also estimate a strong positive relationship with the variable measuring the affiliation to public or private social security. This result may represent evidence that workers and employers’ moral hazard (e.g. the fact that both workers and employers may take fewer precautions because they know they are insured) is stronger than employers’ incentive to reduce occupational risks because the insurance premium is based on their safety record. However, we have to consider that there may be also other contributing factors. For example, if the worker has the right to social security benefits, he or she may be more likely to report occupational injuries or disease in the survey. We tested for simultaneity by re-estimating

---

<sup>4</sup> The Kruskal-Wallis test showed that there were not significant differences in the dependent variables (*impairment*, *temporary impairment* and *permanent impairment*, and *days out of work*) between the observations included in the empirical analysis and the observations excluded because incomplete.

the probit using instrumental variables.<sup>5</sup> The Rivers and Vuong (1988) test did not reject the hypothesis that affiliation to social security is exogenously determined.<sup>6</sup>

In relation to the type of economic activity we found that, compared with the public sector and defense, workers in other economic sectors show a higher probability of suffering from occupational accidents. In particular, the likelihood of reporting work-related impairment is highest among workers in the transport and communication industry, followed by manufacturing, mining and electricity. In third place, we have the service sector, followed by agriculture and farming. Only the construction sector does not statistically differ from the baseline group.

Moreover, workers who have a second occupation are more likely to report work-related health problems. This could be due to longer exposure to occupational hazards, the effect of stress or fatigue, or correlated with particular hazard occupations.

Finally, workers that reside in a different location than the rest of the household (*Migration*) have a higher and statistically significant likelihood of reporting an occupational impairment. On the other hand, remuneration, size of the enterprise, whether the work relationship is based on a temporary or verbal agreement, being self-employed, without a specific premises, and without a salaried work do not appear to be significantly associated with OSH.

---

<sup>5</sup> The instruments used in the IV estimation were variables that were found statistically non significant in the previous estimation: *Married, Self-employed, No Salaried, Small, Large, Temporary, Verbal, No premises*.

<sup>6</sup> The Rivers and Vuong (1988) test of joint significance was  $F(1, 604) = 0.64$ , which is well below the significance level ( $p > F = 0.4275$ ). The F-statistics of the identifying instruments in the auxiliary regressions showed that the instruments were highly significant and the Sargan-Hansen-Newey *J-tests* (Godfrey and Hutton, 1994) suggested that the instruments were valid and the model was not misspecified ( $J\text{-test} = 6.822$ ;  $p > \chi^2(7) = 0.4477$ ).

### ***Bivariate probit model***

We have distinguished between temporary and permanent work-related impairments and we have estimated the two regressions jointly using a bivariate probit model. The results from the estimation are presented in Table 4. The hypothesis that the two regression models are independent ( $\rho = 0$ ) is rejected. Therefore, the bivariate probit model produces estimates that are more efficient than estimating the two models separately.

Even if the estimates are altogether quite similar to the previous model, we can notice some differences between the determinants of temporary and permanent impairments. First, the effect of age on the likelihood of the two types of impairments is quite different. In the case of temporary impairment the maximum is at 50 years of age, while permanent impairments are more likely to be reported at a much older age of 57.

In the regression estimating permanent impairments, *Migration* has a positive and statistically significant impact as well as the variable indicating a *Verbal* contact. On the other hand these two variables are not significant in the regression estimating temporary impairments.

Finally, another difference refers to the variable that indicates the case of a worker without salary, co-operative worker or family worker. In the regression estimating temporary impairments, the variable shows a statistically significant positive coefficient, while in the case of permanent impairments the estimated coefficient is again statistically significant, but negative.

### ***Count data models***

The third econometric model examines the number of *days out of work* due to work-related impairments. Since this variable takes the form of positive count we estimate count data models.

First we estimated the Poisson and NB model.<sup>7</sup> The extreme significance of the goodness of fit statistic in the Poisson model ( $\chi^2(14819) = 142493$ ) indicated that this model was not appropriate.<sup>8</sup> Moreover, the comparison between the Poisson model and the NB confirmed the presence of overdispersion, suggesting that the probability that we would observe these data conditional on the process being Poisson, is virtually zero.

The presence of overdispersion, although consistent with the NB specification, does not necessarily imply that the NB specification is the best model and a plausible alternative is the Zero Inflated (ZI) model. To explain why the ZI model may be suitable in our case, consider the possibility that the decision of not going to work requires some fixed costs. These costs may include the value of time and resources needed to see a doctor and to fill requested forms. Therefore, there may be systematic differences in the statistical process governing the decision about taking days off from work and the process governing the number of days out of work. Zero Inflated (ZI) Poisson or NB models allow for systematic differences in the statistical processes governing observations with zero and observations with one or more counts. This is achieved by combining a dichotomous model governing the binary outcome of the count being zero or positive and a truncated-at-zero model for strictly positive outcomes.

Table 5 presents the estimate of the ZI model, in which the probability of a nonzero count is modeled as a logit function and the number of positive counts is assumed to follow a NB distribu-

tion.<sup>9</sup> The ZI NB model nests as special cases the NB (if the 24 parameters of the logit function are jointly equal to zero), the ZI Poisson (if the parameter  $\beta$  is zero) and the Poisson model (both the previous two cases). These restrictions have been tested using likelihood ratio tests, which are presented at the bottom of Table 5 and show that the ZI NB is preferred over the NB model, the ZI Poisson model and the Poisson model.

In relation to the issue of the interpretation of the regression coefficients, we note that the coefficients on the variables can be interpreted as semielasticity. In other words, the coefficient  $\beta_j$  equals the proportionate change in the conditional mean if the  $j$ -th regressor changed by one unit.

The logit function, which models the probability of observing zero days out of work, shows a “U” shaped relationship with the age of the worker.<sup>10</sup> The minimum is among individuals whose age is 53 years. The ZI NB model for the non zero outcomes shows the same pattern and a maximum at the age of 44.

Interesting differences appear in relation to the educational level. Higher education is a significant factor in the probability of taking no days out from work, but does not affect the number of days. On the other hand, workers without education tend to have fewer days out of work.

Among the other variables, we observe that *Migration* has a negative and statistically significant impact on the likelihood of observing a zero, while it is not significant in the number of days out of work. Workers who are affiliated with a social security system are both less likely to have

---

<sup>7</sup> Results from the Poisson and NB models are not presented in the paper for sake of brevity, but are available from the authors on request.

<sup>8</sup> The  $\chi^2$  goodness of fit test compares the fitted probability with actual frequencies, where the fitted frequencies distribution is computed as the average over observations of the predicted probabilities fitted for each count (Cameron and Trivedi, 1998; p. 155).

---

<sup>9</sup> Since the ZI model assumes the correlation between the two regressions to be zero, the covariate lists of the two models can be identical.

<sup>10</sup> Even if the *age squared* is not significant, *age* and *age squared* are jointly significant:  $\chi^2(2) = 8.68$  i.e.  $0.01 < p < 0.05$ .

zero outcomes and to have more days out of work.

The estimation also shows that remuneration is associated with a higher probability of not taking any days out of work due to work-related impairment. This result is against the expectations

of Thaler and Rosen's (1976) model. However, an explanation is that workers with higher remuneration may incur larger costs if they do not go to work, thus it may reflect the higher opportunity cost of taking time to see a doctor or to process a sick leave. Finally, being self-employed is associated with more days out of work.

## Conclusion

In this paper we have described the situation of OSH in LAC, some of the economics aspects related to workers' compensation for occupational accidents, and we have examined the determinants of work safety using data from a Mexican household survey.

This is the first paper, to our knowledge, to explore empirically the determinants of OSH in a developing country. The analysis offered a number of interesting findings. First, all the estimations showed that the probability of reporting work-related impairments and the related number of days out of work are higher among workers covered by social security compensation systems. This result suggests that workers and employers' incentive to take fewer precautions are stronger than employers' incentives to increase safety at work. An implication for policy is that a stronger experience rating system may be useful to increase precautions at work and to reduce occupational accidents and diseases. Indeed, the recent increase in the experience rating of the IMSS employers' contribution, which changed from 0.348-10.035% to 0.025-15% of payroll, went in this direction.

The second interesting result of the analysis is the absence of any positive relationship between wages and the likelihood of reporting work-related impairment. This result rejects the hypothesis of the hedonic wage model formulated by Thaler and Rosen (1976), which predicts that, *ceteris paribus*, the likelihood of suffering work-related impairment should be associated with higher wages in order to compensate for occupational hazards. Moreover, in the ZINB model wages showed a statistically significant and positive relationship with the likelihood of not reporting any day out for work due to occupational impairment. An explanation is that workers with higher remuneration have higher opportunity cost

for the time needed to see a doctor or to process a sick leave.

Third, the analysis indicated an inverted "U" shape relationship between occupational impairment and worker's age. The peak of this relationship is different between temporary and permanent impairments, as the former are more likely to be reported by workers aged around 41 years, while permanent impairments are more frequently reported around 57 years of age. Moreover, the ZINB showed that workers of 44 years of age reported the highest number of days out of work due to occupational impairments.

Fourth, in relation to the type of economic activity we found that workers from the public sector and defense have the lowest likelihood of reporting work-related impairment. On the other hand, workers in the transport and communication industry reported the highest rate of work-related impairment followed by manufacturing, mining and electricity.

In relation to other characteristics of the contractual relationship we note that the size of the enterprise does not appear to affect occupational safety, while a second occupation and a verbal contractual agreement showed a positive impact on the likelihood of reporting permanent impairments. Moreover, self-employed and workers in enterprises with more than 50 employees reported, on average, more days out of work. However, the latter relationship was only marginally significant.

However, we have to point out some limitations of the analysis. The econometric analysis was based on those workers that were still at work at the time of the survey. This factor may have introduced a bias in the results because those who died or were out of work because of severe disabilities at the time of the survey were ex-

cluded from the sample. In the OSH literature this potential problem is denominated the “healthy worker effect” (Monson, 1986).

In addition, the occurrence of work-related accidents and disease as well as the number of days out of work were self-reported and systematic

differences in the way these events are perceived may exist. Therefore, we cannot exclude the possibility that part of the differences between workers covered and not covered by social security is due to differences in the perception and/or propensity of reporting work-related impairment.

## References

- Cameron AC, Trivedi PK. (1998) *Models for Count Data*. Cambridge University Press, Cambridge.
- Chelius JR. (1982) The influence of workers' compensation on safety incentives. *Industrial and Labor Relations Review*, 35, 235-242.
- Delclos GL, Felknor SA, Morandi MT, Schulze LJ, Tovar LS, Yanes L. (1999) The role of information dissemination in sustainability of international partnership. *Int. J. Occup Environ Health*, 5, 203-208.
- Diamond PA. (1977) *Insurance Theoretic Aspects of Workers' Compensation*. In Blinder AS, Friedman P. (Eds.) *Natural Resources, Uncertainty and General Equilibrium System*. Academic Press, New York.
- Foley MP. (1998) Flexible work, hazardous work: the impact of then temporary work arrangements on occupational safety and health in Washington State, 1991-1996. *Research in Human Capital and Development*, 12, 123-147.
- Frumkin H. (1999) Across the water and down the ladder: Occupational health in the global economy. *Occupational Medicine: State of the Art Reviews*. 14 (3), 637-663.
- Giuffrida A, Iunes R, Savedoff W. (2000) *Economic and Health Dimensions of Occupational Safety in Latin America and the Caribbean*. Sustainable Development Department Technical Study Series No. 121, Inter-American Development Bank, Washington DC.
- Godfrey LG, Hutton JP. (1994) Discriminating between errors-in-variables, simultaneity and misspecific a-tion in linear regression models. *Economics Letters*, 44:359-64.
- Gray WB, Jones CA. (1991a) Are OSHA health inspections effective: A longitudinal study in the manu-facturing sector. *Review of Economics and Statistics*, 73, 504-509.
- Gray WB, Jones CA. (1991b) Longitudinal patterns of compliance with occupational safety and health administration health and safety regulations in the manufacturing sector. *Journal of Human Re-sources*, 26, 623-653.
- IDB (Inter-American Development Bank) (1982) *Economic and Social Progress in Latin America. 1980-1981 Report*. Inter-American Development Bank, Washington DC.
- ILO (International Labour Office) (1998). *Yearbook of Labour Statistics*. International Labour Office, Geneva.
- ILO (International Labour Office) (1999). *Latin America and Caribbean 1999 Labour Overview*. In-ternational Labour Office, Geneva.
- Jones AM. (2000) *Health Econometrics*. In *Handbook in Health Economics*, Newhouse JP, Culyer AJ. (Eds.) North-Holland, Amsterdam, 2000.
- Lanoie P. (1991) Occupational safety and health: a problem of double or single moral hazard. *Journal of Risk and Insurance*, 58, 80-100.
- Lanoie P. (1992) The impact of occupational safety and health regulation on the risk of workplace acci-dents. *Journal of Human Resources*, 27, 643-660.

- Laurell AC. (1989) The role of union democracy in the struggle for workers' health in Mexico. *International Journal of Health Services*, 199, 279-93.
- Loewenson R. (1994) *Small-scale industries*. In Pearce N, Matos E, Vanio H, Boffetta P, Kogevinas M. (Eds.) Occupational Cancer in Developing Countries. IARC Scientific Publications No. 129, Oxford University Press, Oxford.
- Lora E, Marquez G. (1998) *The Employment Problem in Latin America: Perceptions and Stylized Facts*. Office of the Chief Economist Working Paper 371, Inter-American Development Bank, Washington DC.
- McCaffrey DP. (1983) An assessment of OSHA's recent effects on injury rates. *Journal of Human Resources*, 18, 131-146.
- Monson RR. (1986) Observations on the healthy worker effect. *Journal of Occupational Medicine*, 28, 425-433.
- Neumann GR, Nelson JP. (1982) Safety regulation and firm size: effects of the coal mine health and safety act of 1969. *Journal of Law and Economics*, 25, 183-199.
- Oi WY. (1974) On the economics of industrial safety. *Law and Contemporary Problems*, 38, 669-699.
- Partanen TJ, Hogstedt C, Ahasan R, Aragón A, Arroyave ME, Jeyaratnam J, Kurppa K, Loewenson R, Lundberg I, Ngowi AV, Mbakaya CF, Stayner L, Steenland K, Weiderpass E, Wesseling C. (1999) Collaboration between developing and developed countries and between developing countries in occupational health research and surveillance. *Scand J Work Environ Health*, 25(3), 296-300.
- Rea SA. (1981) Workmen's compensation and occupational safety under imperfect information. *American Economic Review*, 71, 80-93.
- Rivers D, Vuong Q. (1988) Limited information estimators and exogeneity tests for simultaneous probit models. *Journal of Econometrics*, 39: 347-366.
- Root N. (1980) Injuries at work are fewer among older employees. *Monthly Labor Review*, Mar, 30-34.
- Ruser JW. (1991) Workers' compensation and occupational injuries and illness. *Journal of Labor Economics*, 9, 325-350.
- Ruser JW. (1993) Workers' compensation and the distribution of occupational injuries. *Journal of Human Resources*, 28, 593-617.
- Thaler R, Rosen S. (1976) *The Value of Life Saving*. In Terleckyj (Eds.) Household Production and Consumption, NBER Press, New York.
- Viscusi KV. (1986) The impact of occupational safety and health regulation, 1973-1983. *Rand Journal of Economics*, 17, 567-580.
- Well D. (1996) If OSHA is so bad, why is compliance so good? *RAND Journal of Economics*, 27, 618-640.
- Winkelmann R. (1997) *Econometric Analysis of Count Data*, 2<sup>nd</sup> edition. Springer Verlag, Berlin.

**Table 1**                      **Occupational fatality rates**

Country	Fatality rate per '000 workers	Employed & covered by ILO data %	Year
Barbados <sup>(b)</sup>	0.000	-	95
Bolivia <sup>(a)</sup>	0.111	23	97
Brazil <sup>(1, 2, a)</sup>	0.150	33	96
Colombia <sup>(2, b)</sup>	0.077	85	96
Costa Rica <sup>(1, 2, a)</sup>	0.069	55	97
Ecuador <sup>(1, a)</sup>	0.168	35	94
El Salvador <sup>(1, a)</sup>	0.330	26	98
Mexico <sup>(1, 2, b)</sup>	0.120	34	97
Nicaragua <sup>(1, 2, a)</sup>	0.096	-	98
Panama <sup>(1, a)</sup>	0.140	65	98
Peru <sup>(a)</sup>	0.186	7	98
Trinidad & Tobago <sup>(b)</sup>	0.010	-	97
Venezuela <sup>(1, b)</sup>	0.006	60	97
Average LAC <sup>(c)</sup>	0.135	-	-
Canada <sup>(2, a)</sup>	0.071	84	97
USA <sup>(2, b)</sup>	0.005	-	97
Finland <sup>(a)</sup>	0.027	82	96
Republic of Korea <sup>(1, 2, a)</sup>	0.290	38	98

Source: ILO (1998).

(1): commuting accidents are included.

(2): occupational diseases are included.

(a): compensated injuries

(b): reported injuries

(c): average weighted by the number of workers covered in each country

**Table 2** Description of the variables

Variable	Description	Mean	Std. Dev.
<i>Impairment</i>	Work-related impairment <sup>(a)</sup>	0.011	0.105
<i>Temporary impairment</i>	Temporary impairment <sup>(a)</sup>	0.0043	0.066
<i>Permanent impairment</i>	Permanent impairment <sup>(a)</sup>	0.0068	0.082
<i>Days out of work</i>	Number of days out of work due to work-related impairment (all worker in the sample)	1.352	26.733
	(only worker reporting work-related impairment)	88.610	146.842
<i>Age</i>	Age	34.499	12.294
<i>Female</i>	Female <sup>(a)</sup>	0.313	0.464
<i>Married</i>	Married <sup>(a)</sup>	0.553	0.497
<i>Education 0</i>	Without education <sup>(a)</sup>	0.081	0.273
<i>Education 1</i>	Primary education (primary completa y incompleta) <sup>(a)</sup>	0.438	0.496
<i>Education Sup</i>	Higher education (medio superior, superior, maestria y doctorado) <sup>(a)</sup>	0.199	0.400
<i>Social Security</i>	Affiliated to public or private social security (as principal affiliated) <sup>(a)</sup>	0.396	0.489
<i>Remuneration</i>	Remuneration from principal occupation (last week in '000 pesos)	2.002	4.520
<i>Agriculture</i>	Agriculture and farming <sup>(a)</sup>	0.207	0.406
<i>Manufacturing</i>	Manufacturing, mining and electricity <sup>(a)</sup>	0.191	0.393
<i>Transport</i>	Transport and communication <sup>(a)</sup>	0.043	0.203
<i>Construction</i>	Construction <sup>(a)</sup>	0.052	0.222
<i>Services</i>	Services <sup>(a)</sup>	0.452	0.498
<i>Temporary</i>	Written employment contract, fixed term <sup>(a)</sup>	0.052	0.222
<i>Verbal</i>	Verbal employment contract <sup>(a)</sup>	0.349	0.477
<i>Self-employed</i>	Self-employed <sup>(a)</sup>	0.300	0.458
<i>No Salaried</i>	Worker without salary, co-operative worker or family worker <sup>(a)</sup>	0.003	0.051
<i>Migration</i>	Reside in a different location than the household <sup>(a)</sup>	0.005	0.073
<i>Small</i>	Enterprises with less than 16 employees <sup>(a)</sup>	0.315	0.465
<i>Large</i>	Enterprises with more than 50 employees <sup>(a)</sup>	0.284	0.451
<i>No premises</i>	Street vendor, and workers without a specific premises <sup>(a)</sup>	0.394	0.489
<i>2 Occupation</i>	Two or more occupations in the last week <sup>(a)</sup>	0.079	0.270

a: Dummy variable taking the value of 1 if yes, 0 otherwise.

Observations: 14,850.

Baseline: male, single, working in the public sector or defense, secondary education, salaried worker, written permanent employment contract, without social security, working in an enterprises with 16-50 employees, with a specific premises and living with the rest of the household.



**Table 4**      **Regression results: Dependent variables *Temporary Impairment and Permanent impairment* – Bivariate probit model**

Variable	<i>Temporary impairment</i>		<i>Permanent impairment</i>	
	Coefficient	Standard Error	Coefficient	Standard Error
<i>Age</i>	0.0946**	0.0380	0.0822***	0.0282
<i>Age^2</i>	-0.0012**	0.0005	-0.0007**	0.0003
<i>Female</i>	-0.3577**	0.1688	-0.5629***	0.1541
<i>Married</i>	0.0610	0.1277	0.0653	0.1143
<i>Education 0</i>	-0.2161	0.1908	-0.1000	0.2075
<i>Education 1</i>	0.0857	0.1454	-0.2164*	0.1259
<i>Education Sup</i>	-0.5290***	0.1990	-0.5350***	0.1700
<i>Migration</i>	0.4411	0.4035	1.0449***	0.3810
<i>Social Security</i>	0.3508*	0.1885	0.3236**	0.1404
<i>Remuneration</i>	-0.0158	0.0172	-0.0234	0.0147
<i>Agriculture</i>	0.4746	0.2934	0.3554	0.2492
<i>Manufacturing</i>	0.6131**	0.2593	0.4471*	0.2321
<i>Transport</i>	0.7568**	0.3368	0.7095***	0.2758
<i>Construction</i>	0.5305	0.3280	0.0107	0.3281
<i>Services</i>	0.4249*	0.2526	0.4100*	0.2279
<i>2 Occupation</i>	-0.1092	0.1674	0.4027***	0.1310
<i>Self-employed</i>	0.0851	0.2080	0.2990	0.2041
<i>No Salaried</i>	0.7392**	0.3456	-6.3432***	0.4275
<i>Small</i>	0.1245	0.2298	-0.2207	0.2461
<i>Large</i>	-0.0807	0.1828	0.2537	0.1609
<i>Temporary</i>	0.0223	0.2408	-0.1423	0.2358
<i>Verbal</i>	-0.0191	0.2118	0.3980***	0.1543
<i>No premises</i>	0.1193	0.1762	0.2369	0.1519
<i>Intercept</i>	-5.0135***	0.8798	-5.1607***	0.6646
<i>?</i>	-0.8226	0.1075		
Log-likelihood	-1578219			
Wald test of $\beta = 0$ [ $\chi^2$ (1)]	12.2668***			

\*\*\* indicates  $p < 0.01$ ; \*\* indicates  $0.01 < p < 0.05$ ; \* indicates  $0.05 < p < 0.1$

Observations: 14,850.

Standard errors adjusted for clustering (basic geographical statistical area).

**Table 5 Regression results: Dependent variable *Days out of work* - Zero Inflated Negative Binomial model**

	Non zero outcome		Zero outcome	
	Coefficient	Standard Error	Coefficient	Standard Error
<i>Age</i>	0.1823*	0.0947	-0.1481**	0.0731
<i>Age^2</i>	-0.0021**	0.0010	0.0014	0.0009
<i>Female</i>	-2.5051***	0.4168	2.0664***	0.6173
<i>Married</i>	-0.4051	0.3262	-0.1444	0.3359
<i>Education 0</i>	-1.4544***	0.4069	0.3649	0.5718
<i>Education 1</i>	-0.2455	0.3029	0.3245	0.3110
<i>Education Sup</i>	0.7458	0.5525	1.9846***	0.5403
<i>Migration</i>	0.2365	0.4262	-2.4627***	0.5463
<i>Social Security</i>	1.4008***	0.3668	-1.0789***	0.3935
<i>Remuneration</i>	0.0057	0.0551	0.0621**	0.0307
<i>Agriculture</i>	0.8278	0.6899	-1.1650	0.8139
<i>Manufacturing</i>	0.6695	0.6337	-1.5053**	0.7611
<i>Transport</i>	1.4179**	0.6700	-1.4112	0.8650
<i>Construction</i>	-0.2751	0.8815	-1.0675	0.8931
<i>Services</i>	0.8006	0.6597	-1.2285*	0.7413
<i>2 Occupation</i>	-0.2761	0.3744	-0.4414	0.3343
<i>Self-employed</i>	1.7060***	0.6586	-0.4211	0.4758
<i>No Salaried</i>	0.0880	1.0180	-0.9484	1.0186
<i>Small</i>	1.0262	0.6604	0.2672	0.6331
<i>Large</i>	0.9039*	0.5135	-0.0070	0.4099
<i>Temporary</i>	0.4694	1.0026	0.5411	0.7603
<i>Verbal</i>	0.9966	0.6539	-0.8816*	0.4656
<i>No premises</i>	0.7949	0.5779	-0.5650	0.4840
<i>Intercept</i>	-1.6872	2.0066	9.9552***	1.6989
<i>Ln(?)</i>	0.0585	0.1645	-	-
Log-likelihood			-1220	
Likelihood ratio test ZINB vs. NB [Inflate = 0 $\chi^2$ (24)]			164***	
Likelihood ratio test ZINB vs. ZI Poisson [ $\chi^2$ = 0 $\chi^2$ (1)]			14389***	
Likelihood ratio test ZINB vs. Poisson [ $\chi^2$ (25)]			172923***	

\*\*\* indicates  $p < 0.01$ ; \*\* indicates  $0.01 < p < 0.05$ ; \* indicates  $0.05 < p < 0.1$

Observations: 14,850.

Standard errors adjusted for clustering (basic geographical statistical area).