

# Differential Socio-Economic Effects of Work Environmental Risk Factors

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## Abstract

Efficient resource allocation in the management of occupational health and safety (OHS) in the workplace requires access to information about the effects of different psychosocial and physical risk factors in the workplace on lost working hours and reduced productivity. The present article aims to help the OHS policy-makers in their decisions on allocating economic and human resources to deal with different environmental risk factors and their socio-economic consequences in the workplace. The socio-economic consequences refer substantially to missed and unproductive working hours due to sickness absences and sickness presenteeism respectively. The methodologies employed to fulfil the purpose of this study included methods to estimate marginal effects of different risk factors on lost working hours and labour productivity. The empirical results of the study showed that the psychosocial and physical dimensions of the work environment of the Swedish company Sandvik Materials Technology had different socio-economic impacts in terms of lost working hours and labour productivity. The psychosocial work environment had the greatest impacts, particularly on reducing work ability and work interest among workers and on work-related disorders among female workers.

**Keywords:** Psychosocial work environment; Ergonomic work conditions; Physical characteristics of work place; Sickness absences; Sickness presenteeism; Labour productivity loss

## Introduction

### Work environment risk factors and their socio-economic consequences

Improvement of the work environment and prevention of work-related disorders require multifactorial health interventions, and these interventions must be based on comprehensive work environment studies. All occupational health hazards have been classified according to the three groups of risk factors concerning psychosocial, ergonomic, and

physical dimensions of the work environment [1,2]. The psychosocial dimension of the work environment contains factors such as stress, depression, violence and insufficient social capital that can lead to health hazards; ergonomic work conditions such as monotony in tasks and awkward body postures at work can lead to musculoskeletal pains; and physical characteristics of the workplace such as noise, temperature and air quality can also affect the health and work capacity of workers. All the mentioned occupational risk factors have significant socio-economic impacts in terms of increasing work-related disorders and decreasing real working hours and potential labour productivity [2-6]. The risk factors have been ranked by workers of a large-scale manufacturing company in Sweden to provide decision-makers with guidance on resource allocation in the investment and efforts for improving the work environment and preventing work-related disorders [2]. However, an efficient allocation of human and economic resources requires an assessment of the differential effects of work environment risk factors on organisational production; the effects manifest themselves in fulfilled working hours and labour productivity. This developing research area has been able to partially assess certain socio-economic impacts of critical risk factors in the ergonomic and physical dimensions of the work environment [3-10]. However, as the used number of scheduled working hours and the level of labour productivity are affected by the interplay and interaction between risk factors, the socio-economic impacts should be assessed when all risk factors in the psychosocial, ergonomic, and physical dimensions of the work environment are considered. Partial studies of work environment that focus on certain risk factors can overestimate and magnify the socio-economic impacts. Also, as efficient resource allocation requires access to information about marginal socio-economic effects of the risk factors, appropriate econometric models should be applied.

Missed and unproductive working hours due to the sickness absenteeism and presenteeism have shown to be associated with different physical and psychosocial risk factors in the workplace. The multifactorial causality has motivated some researchers in the field to suggest multifactorial interventions in work-related health hazards in order to promote occupational health and thus reduce illness-related lost working hours [11,12]. They emphasise in particular the role of the psychosocial dimension of the work environment, whereas partial studies of ergonomic and physical dimensions of the work environment [5-7] tend to either ignore or downgrade of

the effects of psychosocial risk factors on developing disorders, increasing sickness absences, and decreasing labour productivity. The economic costs of work-related disorders to society in terms of labour productivity loss are not only created through physician-certified illnesses such as musculoskeletal disorders [3], asthma [13], and allergic rhinitis [14], but also by mental health problems [15]. Furthermore, the behavioural and psychosocial environment of the workplace has been shown to have a greater effect on labour productivity and fulfilled working hours than the ergonomic work conditions and physical environment of the workplace [12].

## Findings in related works

Studies investigating the psychosocial dimension of the work environment have come up with the following interesting results: lower job control, decreased social support, and increased job demands in the workplace all caused a higher risk of missing working hours due to sickness absences than the physical risk factors, and the mentioned psychosocial risk factors caused an even higher risk to illness when they were all combined [16]; improvement of the psychosocial work environment would reduce sickness absenteeism and presenteeism and thus labour productivity loss in the future [17]; among female workers, even physician-certified illnesses behind lost working hours are more due to psychosocial factors than mechanical exposure [18]; and as an example, the association between psychosocial factors and shoulder and neck pain is shown to be more significant among female workers than male workers [19]. Regarding gender difference in the influence of work-related exposures, relevant studies show that it is also apparent within the same psychosocial work environment. While job control and influence were the major contributors to working hours lost by male workers, high job demands was the largest one among female workers [20].

All relevant studies included certain risk factors, and not all the crucial risk factors in the psychosocial and physical work environment.

## Sickness absenteeism and sickness presenteeism

The working hours lost due to sickness absences and/or impaired attending workers are the main source of the costs of work environment deficiencies to society [2]. The lost working hours are really a potential income source the societies give up due to sickness absenteeism and presenteeism; an indirect economic cost that is estimated to be almost 30 times higher than the related medical care expenditures [2]. Unproductive working hours due to sickness presenteeism, as well as missed working hours due to sickness absenteeism, are respectively the medium- and long-term effects of deficiencies in the work environment, where the current sickness presenteeism can lead to future sickness absenteeism [21,22].

Moreover, relevant studies have found that the lost potential income is mostly due to reduced work performance and work quality rather than sickness absences [2,23-25],

which does mean that present but impaired workers are the largest source of potential income loss. Enterprises typically invest in their employees' professional knowledge and experience in order to improve the quantity and quality of their products supplied to the market. However, the quantity and quality of the firms' outputs are affected not only by the factor of competence of workers, but also by physical and psychosocial health factors among them [26]. Additionally, unlike sickness absences, sickness presenteeism can lead to the production of goods and services of low quality, which can mean future income loss for affected companies through decreasing competitiveness and losing their position in the market.

Presenteeism's large share in total labour productivity loss is dependent on various factors both in the society and in the work environment. The model of "illness flexibility" introduced by Johansson emphasises the determinant factors as workers' ability and motivation to work which is responsible for the large cost share of presenteeism; determinants that, in turn, are influenced by environmental factors such as ergonomic conditions, stressors, and supportive and congenial working atmosphere [27]. However, in addition to work environmental factors such as job demands, teamwork, and ease of replacement, economic factors such as high earnings and low sickness benefit (allowance) can also be reasons why sickness presenteeism accounts for a larger proportion of productivity loss than sickness absenteeism [28]. Thus, in an individual economic decision for either absenteeism or presenteeism, the ill worker using a cost-utility approach compares the possible costs of absenteeism with the utility expected from it [29].

## Objective

The objective of this paper is to investigate the differential effects of psychosocial and physical risk factors in the workplace on the working hours and productivity lost by male and female workers in the Swedish company Sandvik Materials Technology (SMT). The socio-economic impacts of the occupational risk factors will then be compared to the corresponding socio-economic impacts regarding non-work-related factors.

## Methodology

### Data

Data were collected through a work environment study in the large-scale Swedish company Sandvik Materials Technology in May 2015. The study is conducted in the company's main plant in Sandviken. The management, safety unit, health service, and workers of the company were the sources to all data required for this study, while the responses from each party were anonymous to each other and used to the research only. Data on the number of ill workers and missed working hours due to sick leaves were collected by using the database of the company's health service and also a questionnaire in the basis of Harvard questionnaire distributed

by the safety unit among the volunteers; data on the unproductive working hours of workers while attending the workplace could only be collected through the questionnaire, where workers' own judgements were mitigated by the employer's job demands.

A number of 42 male workers and 7 female workers participated in the study, while they mostly worked in the production of different stainless bar and hollow bar for machining as well stainless steel. The workers were 47 years old with almost 14 years' experience in their job on average. They answered the questions in their workplace while the supervisor was in attendance. The workers were asked to assess different risk factors in the psychosocial and physical work environment, their missed and unproductive working time, and whether the risk factors affected their sickness absenteeism and presenteeism.

The risk factors in the psychosocial dimension of the work environment were classified in the following four groups:

- Stress-producing factors at the workplace such as conflicts, instability, job insecurity, high requirements, and unclear expectations.
- Depression-producing factors at the company such as low salary, low status, and limited control.
- Insufficient social capital at the company that encompasses factors such as non-acceptance (alienation), not being valued (ingratitude), and discrimination.
- Perceived violent behaviour in terms of insults, harassment, and bullying.

The physical dimension of the work environment was divided into the following two groups:

- Ergonomic work conditions – the risk factors caused by the static and dynamic muscle work such as lifting and handling heavy objects, repetitiveness, and body postures at work.
- Physical characteristics of the workplace – including environmental factors such as air quality, temperature, noise, lighting, and vibration.

## Quantitative concepts

Two basic concepts were initially estimated for each worker at SMT participating in the study. The first was lost working hours (LWH) during 12 months between 2014 and 2015, which consisted of missed and unproductive working hours due to sickness absenteeism and presenteeism respectively. The other was labour productivity loss (LPL) as the most important potential income source giving up due to the existence of physical and mental health problems in the workplace (i.e., an indirect economic cost of work-related disorders). LPL was estimated by using the amount of illness-related LWH and the marginal revenue product of labour per hour (MRPL/h). MRPL/h indicates the worker's potential contribution to the company's hourly output in terms of money. The measure is affected by technology and work interdependence in the organisational production, and substantially reflected in the national rate of wage per hour – determined in the labour

market as a function of education and experience, and also affected by socio-economic factors such as unemployment and monopsony power. Thus, labour productivity loss was assessed for each of the workers according to the approach of human capital adjusted for labour market failure (imperfections) and team production (HCA-AMFTP). This approach has been recently employed by Rezagholi et al. [2] for assessing the benefits of improving the work environment at SMT, and by Rezagholi in assessing the value of information that would be produced during a proposed work environmental study in the company [1].

## Analytical tools

Econometric models and theories were employed to estimate the socio-economic impacts of the three groups of work environmental risk factors in terms of working hours and labour productivity as the main potential income source forgone due to the existence of health disorders at SMT from May 2014 to April 2015.

The productivity loss as an indirect economic cost to the company was predicted by the following regression equation:

$$LPL = \alpha_0 + \beta \cdot LWH \quad (1)$$

Where, the regression coefficients  $\alpha_0$  and  $\beta$  can be interpreted as follows:  $\alpha_0$  is the constant level of productivity loss independent of health problems at SMT. The constant level is probably determined by education and experience;  $\beta$  is the marginal cost of each working hour in terms of labour productivity lost by workers with health problems. Hence, the marginal cost  $\beta$  is obtained by differentiating the function with respect to LWH as follows:

$$\partial LPL / \partial LWH = \beta$$

Deficiencies in the three dimensions of the work environment have been shown in the workers' points of discontent, which indicate the perceived exposure to risk factors. The marginal effects of the deficiencies in the three dimensions of work environment on their lost working hours and labour productivity were estimated by the following multiple regression equations:

$$LWH = \alpha + \beta_1 \cdot S + \beta_2 \cdot E + \beta_3 \cdot F ;$$

$$LPL = \mu + \gamma_1 \cdot S + \gamma_2 \cdot E + \gamma_3 \cdot F ; \quad (2)$$

where S, E, and F indicate deficiencies in the psychosocial work environment, ergonomic work conditions, and physical characteristics of the workplace, respectively; the intercept  $\alpha$  shows the autonomous working hours lost due to the work-related risk factors not considered in this study such as accidents and also the non-work-related factors such as civil status, individual characteristics, family problems, and abuse of alcohol, drugs, and tobacco; the intercept  $\mu$  shows the autonomous (indirect) cost of the non-considered risk factors in terms of labour productivity loss; the slopes  $\beta_1$ ,  $\beta_2$ , and  $\beta_3$  show the marginal overall effects of the failures in the three dimensions of the work environment on the lost working hours (i.e., the effect of additional units of the respective failures in the psychosocial, ergonomic, and physical

dimensions of the work environment on the lost working hours); and the slopes  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  show the marginal economic costs of respective failures in the three dimensions of the work environment in terms of labour productivity loss (i.e., the potential income giving up due to additional units of the respective environmental exposures perceived by workers).

## Results

The seven tables below contain the differential effects of psychosocial and all physical risk factors in the workplace and also non-work-related risk factors on the working hours and

productivity lost by male and female workers at SMT. All economic costs (i.e., labour productivity losses) are in SEK, rounded to integers. On 13 April 2016, exchange rates from EUR and USD to SEK were 9.24 and 8.08, respectively.

Table 1 shows that over 78% of the total lost working hours in SMT from May 2014 to April 2015 came from unproductive working hours, when exposed workers attended the workplace with reduced work ability and work interest.

Table 2 shows the share of losses that according to workers' judgements were caused by risk factors in the psychosocial, ergonomic, and physical dimensions of the work environment, and by risk factors outside of the workplace.

**Table 1:** Estimated average and total values of lost working hours and their economic costs in terms of labour productivity loss (LPL) in SMT from May 2014 to April 2015. LPL is measured in SEK.

SMT; 2014 – 2015	Average per worker	Totally for SMT
Missed working hours due to sickness absenteeism	101.84	356,457
Unproductive working hours due to sickness presenteeism	363.53	1,272,354
Lost working hours due to sickness absenteeism and presenteeism	465.37	1,628,811
Labour productivity loss at the workplace due to sickness	286,514	1,002,797,786

**Table 2:** Estimated average and total values of lost working hours and their economic costs in terms of labour productivity loss (LPL) due to non-work-related disorders and also disorders related to psychosocial (S), ergonomic (E), and physical (F) risk factors in the workplace of SMT from May 2014 to April 2015. The values of LPL are in SEK.

SMT; 2014 – 2015	S-related disorders	E-related disorders	F-related disorders	All disorders	work-related disorders	Non-work-related disorders
Average lost working hours	55.93	22.78	40.49	131.74		333.63
Average labour productivity loss	36,535	13,888	18,476	109,658		176,855
Total lost working hours	195,738	79,714	141,730	461,103		1,167,708
Total labour productivity loss	127,873,900	48,609,050	64,666,035	383,804,638		618,993,148

In addition, 41%, 45%, and 63% of the workers had been exposed to the psychosocial, ergonomic, and physical risk factors, respectively, during the year-long period of study. While 2%, 6%, and 22% of the workers were unilaterally exposed to the psychosocial, ergonomic, and physical risk factors in the workplace, respectively, 16% of the workers were exposed to all the work environmental risk factors during this period. However, psychosocial deficiencies in the work environment have larger consequences; their effects on the workers' missed and unproductive working hours are the greatest. Besides, the workers who were unilaterally exposed to the psychosocial risk factors had absolutely no sickness absenteeism during the last 12 months without only unproductive working hours at the workplace; the risk factors initially decreased cognitive working ability and motivation to work before they developed disorders among workers. Indeed, more workers are affected by the physical environmental risk

factors in the workplace. However, the impacts (socio-economic consequences) are not of the same magnitude.

The psychosocial work environment had significant effects on lost working hours and their economic costs, affecting workers gradually by: 1) stress-producing factors consisting of unclear expectations, high requirements, instability, and conflicts; 2) depression-producing factors that consist of low salary, low status, and limited control; 3) insufficient social capital in the workplace referring to organisational relations that are affected by alienation, discrimination, non-acceptance, and not being valued.

Perceived violent behaviour was not identified at SMT during the study period.

The ergonomic work conditions had significant effects on lost working hours and their indirect economic costs; these conditions stemmed from awkward body postures while

working and handling heavy objects. Repetitiveness of tasks had a weak effect on the workers' health.

The physical environment at SMT had significant effects on lost working hours and their economic costs; the effects were gradual and caused by noise, poor air quality, and unsuitable temperature. Vibration and improper lighting had weak effects on the workers' health.

**Table 3:** Estimated average values of illness-related lost working hours and their economic costs in terms of labour productivity loss (LPL) concerning male and female workers at SMT from May 2014 to April 2015. LPL is measured in SEK.

Gender differences in SMT; 2014 – 2015	Average lost working hours due to the disorders	Average labour productivity loss due to the disorders
Male workers	441.90	263,840
Female workers	606.19	422,557

**Table 4:** Estimated average values of illness-related lost working hours and their economic costs in terms of labour productivity loss (LPL) for male and female workers, as judged to be caused by psychosocial (S), ergonomic (E), and physical (F) risk factors in the work environment of SMT from May 2014 – April 2015. The values of LPL are in SEK.

Gender differences in SMT; 2014 – 2015	S-related disorders	E-related disorders	F-related disorders
Average lost working hours for male workers	37.57	21.53	38.94
Average labour productivity loss for male workers	23,160	13,267	22,457
Average lost working hours for female workers	148.52	31.86	19.67
Average labour productivity loss for female workers	105,988	18,536	14,857

As shown in Table 3, the average number of working hours and productivity lost by female workers due to their disorders is much higher than for all workers mentioned on Table 1.

The losses by female workers were mostly caused by psychosocial risk factors, as shown in Table 4.

Gender differences also manifest within the psychosocial work environment. While male workers were affected by unclear expectations, low status, instabilities, high requirements and low salary; female workers were affected by high requirements, unclear expectations, instabilities, conflicts and alienation. Information from Tables 3 and 4 confirms that the health and socio-economic impacts of work environmental deficiencies are generally greater for female than for male workers. The impacts of psychosocial and ergonomic risk factors are greater, while the impacts of physical environmental risk factors are minor for female compared to male workers at SMT.

Thus, gender differences at SMT can be summarised as follows: 1) female workers generally are considerably more affected by deficiencies in the work environment as measured by missed and unproductive working hours, and 2) female

workers are more sensitive to deficiencies in the psychosocial work environment and ergonomic work conditions, while they are more resistant to deficiencies in the physical environment of the workplace.

Analysis of the regression equation (1) for economic costs produces the following results:

The estimated regression equation is  $LPL = 1650 + 612.1 \cdot LWH$ ; and the statistical specifications are summarised in Table 5.

**Table 5:** Estimated economic costs of sickness absenteeism and presenteeism, using ordinary least squares (OLS) regression analysis ( $R^2 = 90.43\%$ ).

Parameter	Regression coefficient (Standard error)	T-value	P-value
a	1,650 (16,202)	0.10	0.919
b	612.1 (29)	21.08	0.000

The value of 612.1 SEK shows the marginal cost of losing one working hour due to employee disorders in the company from May 2014 to April 2015; an economic cost related to the labour productivity loss. The value of 1,650 SEK shows the autonomous average cost of sickness absenteeism and presenteeism for each worker during the period in terms of labour productivity loss; an economic cost that may not be reduced by improving mental and physical occupational health, while it determines by factors out of the regression model. However, the value is not statistically significant, and thus care should be taken in the performance of any programme to recover the cost.

Analysis of the regression equation (2) for work-related exposures at SMT from May 2014 to April 2015 gives the following results:

The estimated regression equations are  $LWH = 80 + 11 \cdot S + 4.72 \cdot E + 6.58 \cdot F$  and  $LPL = 47,299 + 5,595 \cdot S + 3,645 \cdot E + 3,861 \cdot F$ . The equations show the significant marginal effects of work-related exposures on working hours and labour

productivity lost by workers in the company. The statistical specifications are summarised in Tables 6 and 7.

**Table 6:** The marginal effects of work-related psychosocial, ergonomic and physical exposures on the company's lost working hours, using OLS regression analysis ( $R^2 = 77.46$ ).

Parameter	Regression coefficient (Standard error)	T-value	P-value
$\alpha$	80 (45)	1.78	0.083
$\beta_1$	11 (2.4)	4.58	0.000
$\beta_2$	4.72 (2.12)	2.23	0.031
$\beta_3$	6.58 (2.5)	2.63	0.012

**Table 7:** The marginal economic costs of work-related psychosocial, ergonomic and physical exposures, using OLS regression analysis ( $R^2 = 71.23$ ).

Parameter	Regression coefficient (Standard error)	T-value	P-value
$\mu$	47,299 (25,758)	1.84	0.073
$Y_1$	5,595 (1,745)	3.21	0.002
$Y_2$	3,645 (1,541)	2.37	0.022
$Y_3$	3,861 (1,819)	2.12	0.039

The statistical outcomes of the regression analyses in Tables 6 and 7 can be economically interpreted as follows:

The value 80 is the number of working hours that each worker at SMT lost on average due to non-work-related factors from May 2014 to April 2015. The effect is statistically significant at a 10% level. The average cost of the non-work-related risk factors for the company in terms of labour productivity lost by each worker during the period was 47,299 SEK. The cost is also statistically significant at the same level.

The value 11 h is the average number of working hours lost by each worker at SMT from May 2014 to April 2015 due to each additional unit of deficiency in the psychosocial work environment (i.e., each additional point of discontent or perceived exposure to risk in the psychosocial work environment). Its corresponding cost (i.e., the marginal cost of each perceived psychosocial exposure) was 5,595 SEK in terms of labour productivity lost by each worker at SMT during this period.

The value 4.72 is the average number of working hours lost by each worker at SMT from May 2014 to April 2015 due to each additional unit of deficiency in the ergonomic dimension of the work environment. Its corresponding cost (i.e., the marginal cost of each perceived ergonomic exposure) was 3,645 SEK in terms of labour productivity lost by each worker at SMT during this period.

The value 6.58 is the average number of working hours lost by each worker at SMT from May 2014 to April 2015 due to each additional unit of deficiency in the physical environment of the workplace. Its corresponding cost (i.e., the marginal cost

of each perceived physical exposure) was 3,861 SEK in terms of labour productivity lost by each worker at SMT during this period.

Hence, the labour productivity losses are economic costs and not accounting costs. The economic costs are the potential incomes giving up by SMT when deficiencies in the work environment caused mental and physical health problems.

## Discussion

Compared to the similar economic studies of the work environment [16-20], this study covered more crucial risk factors in the three dimensions of the work environment, and used more developed methodologies and advanced economic theories to assess the economic costs. The results of this study can therefore be used for making efficient economic decisions on investment in the work environment and for providing effective multifactorial health interventions. While the empirical results of this study confirm the findings of the similar studies, they highlight the need of providing extensive work environmental studies with economic perspective. There are some limitations with this study that should be discussed.

### Absenteeism versus presenteeism

As mentioned in the results section, workers with reduced work ability and work interests caused 78% of the total illness-related lost working hours at SMT during 12 months between 2014 and 2015. Generally, there are many factors inside and outside of the workplace which determine the rate of substitution between absenteeism and presenteeism on the appearance of a health problem. The rate of the substitution is a result of the individual decisions made by affected workers between the two possible behaviours: enrol as sick and stay home, or be at workplace and work at low capacity. There are various organisational, individual, and societal factors that determine how the decision problem will be resolved. Factors that constrain the opportunity for ill workers to be absent and stay home stimulate them to attend the workplace and work at reduced work capacity. The findings of relevant research clearly show that factors such as low or no sickness benefit (allowance), attendance control, downsizing, short-term contracts, rental employees, ease of replacement, and teamwork stimulate ill workers to attendance in the workplace [29]. Some of these factors were present in the company and in Swedish society from 2014 to 2015; such as the existence of qualifying, which means no allowance for the first sickness day for the worker signed off as sick, ease of replacement (because of high unemployment), attendance control, and teamwork. Thus, although there are difficulties and uncertainties associated with the measurement of sickness presenteeism [2], a larger proportion of the presenteeism would not be unrealistic due to the existence of the factors influenced workers' individual decisions.

The other reason for the large proportion of the sickness presenteeism relates to the higher short-term impacts of work environmental deficiencies on reducing cognitive work ability and work interest. Likewise, deficiencies in the psychosocial

work environment have definitely a larger impact. It is indicated that deficiencies in the three dimensions of the work environment had two effects in terms of time: 1) the short-term effects of the deficiencies manifest in reduced cognitive work ability and work interest; and 2) the medium- and long-term effects of the deficiencies usually translate into increased sickness absences. Policy makers in workplaces should thus take sickness presenteeism very seriously because its enormous economic costs are not limited to present reduced work ability and interest, but can extend to increased sickness absences in the future.

Therefore, as the most of the lost working hours consist of unproductive working hours at the workplace that mostly caused by the psychosocial risk factors, the investments in improving the psychosocial work environment is considered as an effective and profitable economic decision making.

### Gender differences

The results showed that female workers were more sensitive to psychosocial and ergonomic risk factors, while they were more resistant to risk factors in the physical environment such as noise and low air quality (air pollution). The gender difference led, on the whole, to more working hours that were lost by the female workers. However, although the results are broadly consistent with many reports from Scandinavian workplaces and with the findings of similar research [21-23], one should be careful with the generalisation of this result. Relatively few female workers participated in the study compared to male workers (7 against 42), and although the related values are characterised by low standard errors, the low number of female participants can theoretically bring uncertainty. Studies in the company using a larger sample size would be needed to confirm whether the relatively small sample of female workers biased the profile of gender differential effects of the three work environmental dimensions on health and labour productivity.

### Omitted work-related exposures to risk of disorders

A total of 22 risk factors were considered in the survey of the work environment at SMT performed during May 2015: 14 psychosocial (stress over high requirements; stress over unclear expectations; conflicts; job insecurity; instability; low control; low salary; low status; discrimination; ingratitude; alienation; harassment; insults; bullying), 3 ergonomic (handling heavy objects; repetitiveness; working body postures), and 5 physical (air pollution; improper temperature; noise; improper lighting; vibration). However, there have been risk factors in the three dimensions of the working environment that were omitted or not exactly covered by the predefined risk factors. The most important of these are allergens and accidents that could have significant socio-economic consequences in terms of lost working hours and labour productivity. The measure of total work-related disorders was considered in the present study in order to capture the socio-economic impacts of work-related risk

factors that were omitted or not fully covered. The significant difference between the values related to total work-related disorders and the sum of the S-, E-, and F-related disorders could reveal the omitted risk factors in the workplace, and in particular the exposure to allergens associated with various substances and accidents when executing different tasks.

### Work-related versus non-work-related risk

The results showed that the socio-economic consequences of non-work-related disorders were much greater than the corresponding consequences of the work-related disorders at SMT. The big differences show that the larger source of critical exposures and risk factors for illness among company workers lies outside of the workplace (Table 2). However, it could be biases and uncertainties associated with the relative assessments of work-related and non-work-related disorders, for two main reasons: 1) it is certain that the workers participating in the study had difficulties in distinguishing and separating all their sickness absences and impairments at work between the work-related and non-work-related categories; and 2) many of the disorders among the company workers can be a result of combined effects of work-related and non-work-related risk factors, which could make the assessments even more difficult to establish.

### Conclusions

Psychosocial work environment, ergonomic work conditions, and physical characteristics of the workplace have different socio-economic impacts in terms of fulfilled scheduled working hours and labour productivity. The assessment of their differential effects in the Swedish company Sandvik Materials Technology (SMT) showed that the psychosocial work environment had the greatest socio-economic impacts, particularly on unproductive working hours due to the reduced work ability and work interest among workers, and also on the work-related disorders among female workers. In addition, the stress-producing factors at the workplace such as unclear expectations, high requirements, instability, and conflicts affected the workers more than other psychosocial risk factors. Moreover, the crucial physical risk factors such as awkward body postures while working, handling heavy objects, noise, poor air quality, and unsuitable temperature caused an even higher risk to illness, and thus greater socio-economic impacts, when they were combined with the psychosocial risk factors.

The efficient economic decisions on the work environment of the company would initially manifest in the prioritization of investment in the psychosocial work environment in order to increase work (cognitive) ability and work interests.

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