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How to promote prevention—economic incentives or legal regulations or both?

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Legal regulations of the work environment are probably regarded as the main tools for promoting prevention at the workplace. Legal regulations are expressed as occupational exposure limits, bans, and taxes. Taxes can be regarded as economic incentives as well, and other economic incentives are insurance systems for employers' and consumers' actions. The latter have been found to have profound effects regarding environmental issues and may also, in the future, be a powerful tool for workplace-related prevention. The research in this area is rather limited, but there are some research results that can be obtained from the area of environmental economics. This paper discusses some examples in which legal regulations, economic incentives, or both have been used. Legal regulations and market-based economic incentives may produce similar results, but the economic cost and political feasibility typically differ. This situation makes the selection and design of instruments an important field for future research

Key terms bladder cancer, labor unions, occupational, silicosis, trichloroethylene.

Occupational exposures may cause adverse effects on exposed workers. The effects range from reversible conditions, such as slight respiratory irritation, to irreversible and serious conditions, such as solvent-induced encephalopathy. In addition to the previously well-known work-related diseases, less described ones, such as stress-related disorders, hypersensitivity problems, and various psychosocially related disorders, have emerged during the last few decades. For these latter conditions our knowledge about the causative factors (exposure) is rather low, and this lack of knowledge adds to the difficulties of preventing these conditions. Hence the incentives for preventive actions may be different regarding, for instance, psychosocially related disorders than for diseases related to exposure to chemicals.

The policy instrument chosen for the prevention of occupational ailments should, for each situation, be based on the optimal combination of effectiveness, efficiency, and political feasibility. For instance, when the exposures are associated with high risks for serious diseases, such as cancer, then precaution may dictate the use of some very powerful instruments, such as bans (1).

In 1991 a debated study was published showing that tough environmental regulation in the form of economic incentives may encourage the technological development in affected enterprises (2). In the long run, this step was thought to increase their competitiveness and thus compensate for the costs due to regulation. This hypothesis has been heavily criticized by most economists on the grounds of its logic: If the companies can save money through certain measures then why do they not undertake these measures irrespective of legislation? The support offered by Porter (2) is mainly based on case studies. Several mechanisms have been proposed to explain this "win-win" situation. One is that enterprises are not aware of certain opportunities, and the regulations

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force them to create new solutions. Another mechanism is that the firm would like to be a first-mover, which, in the long run, is beneficial for its reputation.

Often it has been assumed that there were only two instruments, legal regulations or economic incentives. However, in fact, many instruments with varying characteristics exist. To be effective, legal regulations must be backed up by economic sanctions, and economic incentives are based on some kind of legislation. Figure 1 shows a proposed taxonomy for different instruments.

Legal regulations

In many industrialized countries sophisticated legal systems have emerged that take into account medical, technical, and political aspects when health hazards are regulated in the workplace (3). These regulations are to be regarded as a normative expression of what society considers acceptable conditions for an employer to provide in different kinds of production.

Occupational exposure limits. The cornerstones of legal regulations are occupational exposure limits (OEL). The history of the systematic setting of OEL values started in 1948 when the American Conference of Governmental Industrial Hygienists (ACGIH) published the first comprehensive list of OEL values, termed threshold limit values (TLV). This list was soon adopted by several other industrialized countries, and, in Sweden, the first official list was published in 1960 (4).

In Sweden the first OEL for styrene was 210 mg/m^3 (50 ppm), decided in 1975. The limit was subsequently lowered in 1979 to 170 mg/m^3 (40 ppm), and in 1981 to 105 mg/m^3 (25 ppm). These rapid reductions of the OEL values for styrene caused considerable resistance from industry, especially since other countries had higher limits (5). The Swedish National Board of Occupational Health and Safety was also heavily criticized for underestimating the related costs to industry. Hence industry announced intentions to close down and move production abroad. The consequences of these reductions have been evaluated (5). Small enterprises with low profitability and unacceptable work environments went out of business. In the remaining industry, the rules accelerated necessary changes in technology and eliminatory measures. In the long run, this step was concluded to be beneficial for industry. Some enterprises moved abroad, but it was the prospect of low wages more than the need for low OEL values that was the main cause. Frostling's study (5) can be viewed as support for the Porter hypothesis (2) that environmental regulation increases productivity due to the secondary effects on technological changes.

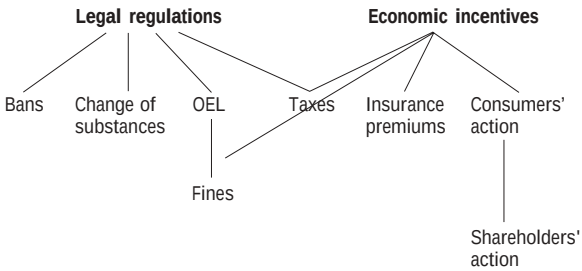

Figure 1. Proposed taxonomy for different kinds of incentives to promote prevention. (OEL=occupational exposure limit)

Bans. Bans on use or manufacture of certain substances have been applied for a limited number of substances, mainly carcinogens. The first ban was issued in 1872 when Finland placed an absolute ban upon the manufacture, use, or sale of white phosphorous matches (6). Denmark took similar action in 1874. A more recent, well-known ban was issued in 1953 in the United Kingdom against 2-napthylamine because of the increased risk of causing bladder cancer (7). This ban was supported by the British chemical industry, as it was considered necessary to hinder unscrupulous manufacturers from taking over the production of these amines when they were abandoned by established industry. Most industrialized countries today have lists of banned carcinogenic substances. In Sweden the use of crocidolite was banned in 1976, and this step essentially resulted in a total closure of the market for the enterprises operating in this sector. This was a controversial decision that caused much debate in Sweden, as well as abroad (8–9). In 1996, France followed the Swedish example and issued a ban on the use and manufacture of asbestos. This step was challenged by Canada. The dispute was processed by a panel within the World Trade Organization (WTO), which decided in September of 2000 to withhold the French ban on the import and use of asbestos (10). In 1991, Swedish Parliament decided to ban the professional use of trichloroethylene (TCE) from 1996 on. This ban is discussed later in this paper.

Compliance. One problem is to verify and improve compliance with legislation. Public resources for the necessary control are often lacking. In Sweden, there are 350 labor inspectors to control about 300 000 enterprises. This is a major problem, as the combination of a regulatory system and weak or nonexistent control of compliance emits ambiguous signals to employers. The issue of compliance has gained much attention in economic research. It has been observed that enterprises

surprisingly have a rather high compliance with regulations, even if the control is weak (11). One explanation that has been put forward is that compliance gives market advantages due to improved reputation.

However, a low level of compliance was indicated in a recent survey from the chemical industry in England (12). It showed that most of the safety representatives in the chemical industry were unaware of the legal regulations. Furthermore, the researchers interviewed 1000 managers responsible for health and safety and 150 trade union representatives about their knowledge regarding relevant legislation (12). About 60% of the managers understood the term "occupational exposure limit", and when requested to define their understanding only a minor fraction mentioned the need to keep the exposure below the OEL. This situation indicates that the real understanding of OEL values is very limited. This opinion was further underlined when the researchers read 10 statements to those claiming to understand the term "occupational exposure limit". Among the statements were two false ones, one claiming that the intention of OEL values "is to decide the maximum number of people who can use the substance at any one time". When scoring this statement between 1 and 10 depending on how strongly they associated this with OEL values (1=not associated, 10=strongly associated), the heavy users scored 5.1. The trade union representatives were, in general, better informed than the managers.

The British survey also showed that most users rely heavily on information from suppliers of equipment and chemicals and less heavily on trade associations or other professional organizations (12). Similar findings have been published in a study from Minnesota in the United States (13). This situation indicates that information is a prerequisite for other instruments to work, and public disclosure to information has lately come to be looked upon as an instrument in its own right.

Economic incentives

At the individual level, society has often chosen to promote preventive actions through a mixture of policies that includes economic incentives. One example is the primary prevention of lung cancer by decreasing tobacco smoking, for which several studies have shown a price elasticity of about –0.5 (ie, for every 1% price increase, cigarette consumption decreases by 0.5%) (14). On the other hand, as shown by others, various other policies, such as information and smoking bans in restaurants, are also potent policies, and the optimum mix of policies is different for different target groups (15). Thus some policies may have a greater effect in delaying the initiation of smoking by youngsters, and others may have more effect in helping adults to quit smoking.

Economic incentives for promoting the prevention of occupational ailments probably need to be at the group level (workplace, nation). In the field of environmental economics, the implementation and efficiency of different policy instruments is already an established research field (16). An important feature for market-based policy instruments to work is the existence of some physical flow that can be measured. The flow may be of certain substances (eg, TCE), which can be taxed, but it could also be the flow of diseased workers. In this latter case, the economic incentive would be in the form of insurance premiums. One problem with economic incentives is that they are based on the result of one or more quantitative key values. If these indicators are not well chosen, there is an apparent risk that these figures will be subjected to manipulation in order that economic benefits be reached.

Taxes. Economic incentives may take the form of taxes (or possibly charges or subsidies) on enterprises with "bad practice", for instance, the lack of access to occupational health services. There are, however, few examples regarding occupational health and safety. An early example (and one of the few) is when Russia placed a heavy tax on white phosphorous matches in 1892, followed in 1912 by the United States, when Congress put a heavy tax on these matches (6).

An alternative is to encourage "good practice" by providing tax reductions for enterprises with validated health and safety expenditures (17–18). One proposal made by a recent Swedish national commission was reduced taxes for employers promoting physical and cultural activities a few hours per month (19).

Insurance premiums. Another option that has recently begun to be discussed is a link between occupational health outcome and insurance premiums. In Europe, insurance for occupationally related diseases and injuries is organized by private and public insurance companies or by the state. For the most part, insurance premiums are levied at a flat rate, but they can also vary according to the disease outcome in different industrial sectors. When the premiums are linked to disease outcome, employers become more aware of their true costs as regards production and may act to reduce the costs. There are, however, disadvantages with such a system. It is claimed that employers would use medical tests to select the most healthy workers (ie, dismiss the slightly disabled ones). This practice is probably associated with employment rate. In societies with a high rate of employment such a situation is less likely to happen. Another disadvantage is that employers may put pressure on workers not to claim for diseases or accidents. Regarding diseases, they may also reflect past conditions

more than future risks. It is also of importance to classify the outcome according to severity; otherwise employers with frequent minor accidents would be penalized when compared with enterprises with few but severe diseases or accidents.

Audits. A third alternative would be to link economic incentives to audits and the presence of intervention programs (17). This practice has been used in Canada, where employers can voluntarily join the program and undergo annual audits. The employers are scored, and the most outstanding ones receive economic incentives as high as USD 2 million. Requiring, or encouraging companies to apply for, environmental certification is a mechanism to ensure that companies have an incentive to upgrade their environmental and occupational health-related management routines.

Information provision, reputation and consumer's action groups. Most pressure groups, such as consumers' action groups, are active in the field of the external environment, but there are few, if any, examples from the occupational environment. The change of bleaching processes for pulp in the Swedish pulp and paper industry is an example of how public opinion regarding external environmental pressure also affects the work environment (20). During the 1980s there was much public concern about effluents to the sea from pulp mills with chlorine-based bleaching. Less or no attention, however, was paid to the fact that the workers at the mills with chlorine-based bleaching had an increased risk for obstructive airway disease (21). The environmental concerns resulted in very advanced plans from the Swedish Environmental Protection Agency to introduce an environmental tax on chlorine. However, the industry decided to be a "first mover" and introduced new bleaching chemicals. Initially chlorine was replaced with chlorine dioxide, and subsequently totally chlorine-free methods were introduced. Some of the methods, for instance, ozone-based bleaching, initially caused large health effects for the exposed workers (22). However, other methods based on oxygen and hydrogen peroxides undoubtedly improved the work environment for bleachery workers.

Some enterprises and industrial organizations use their position as purchasers (consumers) of chemicals and goods. For instance, both Volvo and SKF in Sweden use their position to confront different suppliers with stipulations about issues regarding the work environment. Such initiatives improve the information received by the relevant actors in the field, safety representatives, company physicians and purchasers of chemicals. In the long run, this action increases the pressure on producers of chemicals to declare the composition of their products and to develop less hazardous products.

Case studies

The implementation of different incentive strategies for workplace-based prevention has seldom been investigated. We have, however, selected a number of well-known hazardous occupational agents for which different incentive strategies have been used.

Silica and silicosis. Silicosis is caused by dust containing crystalline silicon dioxide. There are different forms of crystalline silicon dioxide, quartz, tridymite and cristoballite. As compared with quartz, the two latter ones are associated with a higher risk to induce silicosis. At high temperatures quartz is partially transformed to tridymite and cristoballite. Silicosis, which is a form of pulmonary fibrosis with a known etiology, is the result of inhaling more dust than the lung can eliminate. Silicosis was noted already in the 1730s when Carl von Linné observed that sandstone workers quarrying and manufacturing grindstones in Orsa in the middle of Sweden died young from a pulmonary ailment (23). The wives and children were not affected, and he therefore concluded that the ailment was occupational. In the 1850s and 1860s physicians in Pennsylvania, in the United States, recognized an increased prevalence of "miner's asthma" or "miners consumption" among coal miners in this area (24).

In the 1930s an epidemic of silicosis occurred in a variety of industries. The introduction of sandblasting and pneumatic tools, and other mechanical devices increased exposure to silica dust. In the steel and iron industry there were increasing demands for castings due to an increased production of machines and vehicles. In particular, there was an increased demand for steel castings, and steel required higher temperatures than iron to melt. Consequently, the proportion of the more hazardous forms of crystalline silica increased in foundries.

The recognition of silicosis as an occupational ailment was slow, partially because of the difficulties to differentiate between tuberculosis and silicosis, but also because researchers had great difficulties devising experiments that persuasively established the causal chain between silica dust exposure and actual disease. Sweden was the first country, in 1931, to recognize silicosis as an occupational ailment.

As the laws for industrial insurance covered silicosis, employers were interested in investigating the spread of the disease. During the period 1930–1960 much of the preventive work regarding silicosis was driven by enthusiastic physicians and industrial hygienists supported by the national employer and union

organizations (23, 25). The interest at the governmental level was low. The consultants proposed primary prevention (ie, exposure reduction) but national (governmental) policy was secondary prevention. There was progress, however slow, but the incidence of silicosis remained high. During the 1960s political pressure from labor unions and rising public opinion demanded action on occupational and environmental issues. As a result, the government increased its commitment to the problem of silicosis. The increased commitment resulted in extensive occupational hygiene surveys and increased attention to OEL values for silica dust. In the 1970s, industry invested in various forms of equipment to reduce dust levels. During 1970–1975 about 30% of the investments in Swedish foundries were related to environmental demands (26). In addition, during the same period, the introduction of olivine sand as a substitute for quartz resulted in great improvements. Olivine did not cause silicosis, and, in 1975, 65% of Swedish steel-castings were cast in olivine sand instead of quartz sand. Olivine sand was three times as expensive as quartz sand, however.

In conclusion, the preventive work regarding silicosis was, until 1960, the result of joint cooperation between unions and employers, with marginal results. In the 1960s the government increased its involvement, the result being tougher legislation and more funding for comprehensive screening projects. This step led to a substantial increase in environmental investments, and, also in the 1980s, there was a marked decrease in the numbers of new cases of silicosis (table 1).

Exposure to 2-napthylamine and bladder cancer. In 1895 a German physician reported about four cases of bladder cancer in a factory producing fuchsine from aniline (27). He falsely attributed the risk to aniline, but the causative agent was probably 2-napthylamine. In 1938, this substance was shown to induce bladder tumors. The first conclusive epidemiologic study came from England (28), where they described a 30- to 40-fold increased risk for bladder cancer for those working with 1- and 2-napthylamine, but not for workers exposed to aniline.

These results caused the regulatory agencies to take active steps, and two different approaches were used (29, 30). In the United Kingdom, bladder cancer was accepted in 1953 as a prescribed occupational disease, meaning that diseased workers could claim compensation. In 1967 further action was taken as the government prohibited the manufacture and use of 2-napthylamine in the United Kingdom. However, there were some carefully defined exceptions. In the United States, it was decided to regulate strictly the use of 2-napthylamine to minimize occupational exposure. In both countries the use of 2-napthylamine has ceased. In the United States, 2-napthylamine has, for many years, only been used in research. There were several reasons for this success (in both countries). The availability of alternative substances was important; 2-napthylamine was replaced by sulphonate 2-naphtol (30, 31). The economic consequences were marginal. Compare, for instance, the previously discussed quartz issue in foundries, where the prescribed hygienic actions put a major economic pressure on the employer. Furthermore, an important factor was that the epidemiologic evidence regarding 2-napthylamine and bladder cancer was overwhelming.

Trichloroethylene. Chlorinated solvents have long been used for degreasing and dry cleaning. The use has been widespread, and the most common ones have been trichloroethylene (TCE), perchloroethylene (PER), and methylenechloride. Exposure to TCE has been associated with an increased risk of kidney cancer, liver cancer, and different hematological malignancies (32). Regarding the external environment, TCE has been judged to be an environmental carcinogen, and especially the pollution of drinking water has caused concern. It has also been considered a hazard because of its chlorination, since it may contribute to the formation of dioxins. Slunge & Sterner (1, 16) have pointed out that, despite very different regulatory actions in three different countries, the resulting decreased use was similar.

In 1991 the Swedish Parliament decided to ban the professional use of TCE from 1996 on, and the use in consumer products was banned from 1993 on. This was a very tough policy, and it resulted in strong opposition within industry. In 2000, the Court of the European Union also concluded that the Swedish ban did not run counter to European Union legislation. However, the use of TCE began to decrease before the decision concerning the ban was reached, probably as a result of its previously recognized occupational hazards. The increased

Table 1. Reported cases of silicosis in Sweden in 1926–2001.

Period	Annual number of new cases [a]
1926–1930	2
1931–1935	56
1936–1940	87
1941–1945	110
1946–1950	107
1951–1955	75
1956–1960	41
1961–1965	54
1966–1970	63
1971–1975	45
1976–1980	33
1981–1985	25
1986–1990	8
1991–1995	4
1996–2001	2

[a] The mean annual numbers in each 5-year period is presented.

awareness of its occupational hazards could be seen in the tougher OEL values for TCE, resulting in a strong pressure to minimize its use. The OEL (TLV) was reduced in 1984 from 110 to 50 mg/m^3.

An alternative policy was adopted by Norway. The Norwegian government decided to put a tax on the use of TCE from 2000 on. The tax was EUR 5 compared with a market price of about EUR 1 to 1.50. In the year 2000, the use of TCE dropped drastically so that Norway appeared to "catch up" with the reduction that was more continuous during the 1990s in Sweden. Half of the tax is refunded to industry, which reduced its political resistance (16). The refunding could be used for research on alternative degreasing methods or to promote investments in new technology.

Germany adopted a third policy. By tradition, German authorities have a strong belief in technical progress and good engineering. Hence they demanded very tough technical requirements concerning emissions. They issued several additional technical and workplace requirements demanding totally closed systems for the use, storage, and transport of TCE. This approach has lead to very sharp declines in its use and also to an advanced technology that German companies are now able to make money from, through exports to other countries that are starting to regulate TCE.

Special topics

Labor unions. Workers have organized trade unions to strengthen their efforts at improving the work environment, job conditions, workhours, wages, job contracts, and social security. Cooperation between workers and their organizations and professionals has been instrumental in improving regulation and legislation affecting workers' health, and several examples of a positive influence of labor unions exist (33). It has been shown that workplaces with full union recognition and a joint union-employer safety committee have lower serious injury rates per 1000 workers than workplaces without unions and no joint committee (5.3 versus 10.9) (34). Hence it seems reasonable to assume that trade union representatives are key players in passing on and processing information to workers and users. It is probably of importance to defend and support labor unions and the strengthening of their influence on workplace health promotion.

Interaction with demands regarding the external environment. The implementation of a tougher policy towards environmental pollution also affects the work environment by reducing the exposure levels within the workplace (5). The low odor threshold for styrene, 0.05 ppm, forced the Swedish environmental authorities to stipulate lower emissions and also indicated maximum emission levels for the reinforced plastics industry. To fulfill these requirements, investments had to be made in new technology, which also caused an improved work environment. Similar developments have occurred in the chloroalkali industry, in which tougher regulations for the external environment also resulted in decreased occupational exposure to mercury.

Discussion and concluding remarks

By tradition, the implementation of occupational health safety has relied on legal regulations. The efficacy of these regulations has been evaluated to a surprisingly low degree. In the field of environmental policy implementation, research activity has been considerably higher (16, 35), showing that economic incentives are at least as effective as legal regulations and, in many cases, that they are economically more efficient. For comparison, public policy intervention to reduce tobacco use has recently been reviewed; the review concluded that the most potent instruments against tobacco use have been efforts to increase the financial costs of using tobacco products, such as taxation or advertising campaigns (36).

If legal regulations are to be effective, they must be backed up by measures of control and sanction. The sanctions will often be economic sanctions such as fines, although criminal sanctions are also possible.

In a system with market-based economic incentives, the free flow of information is of utmost importance. Workers must, represented by unions, have the possibility to make proper risk calculations about their occupations; in other words information about the used products must be available. National authorities or insurance companies must have access to the number of diseased workers in different trades or enterprises so that they can estimate proper insurance premiums.

In conclusion, legal regulations and market-based economic incentives may produce similar results, but the economic cost and political feasibility typically differs. This situation makes the selection and design of instruments an important field for future research.

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