SERIOUS OCCUPATIONAL INJURIES BY "ACCIDENTS"

Possible means of prevention and injury mitigation

by

Torgny Jarl

Umeå 1989
Serious occupational injuries by "accidents"
Possible means of prevention and injury mitigation

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Serious occupational injuries by "accidents". Possible means of prevention and injury mitigation

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ABSTRACT

An analysis of the circumstances preceding severe occupational injuries as a consequence of impacts has shown that well-known risks are of great importance in 75 per cent of the cases. This indicates that the subjective cause "neglect" is common. The negligence is distributed to the same extent among employers as among employees. Negligence by the employers was defined as obvious violations according to the Law of Workers' Safety or Regulations issued by The National Board of Occupational Health and Safety. Negligence by employees was defined as actions against specific orders or common sense.

As a result of this study additional research concerning the execution of Criminal Law in occupational accidents has been carried out. The law has also been changed regarding prosecution in cases of breaking the Law on the working environment.

In situations where elimination of risks is not possible it is a most important task to minimize the risk of severe injury. In four of the studies there are examples of minimization of injuries by increased usage of personal safety equipment, improved rescue and by modifying the environment.

If personal safety equipment could be used in all relevant situations the incidence of severe injuries at the place of work would decrease by more than 25 per cent. However, the crucial insufficiencies as to the specifications of personal protective equipment must be emphasized. This should stimulate the development of environmental changes, thus preventing the build-up and release of potentially dangerous energy.

Working alone and late rescue for other reasons, together with other circumstances following the injury made the injuries worse in a little more than 10 per cent of the cases.

In the studies concerning injuries as the result of impacts in trucks and buses it is shown that a lot of trucks turn over and that a large number of injuries occur as a result of deformation of the cabins. A safety belt would offer good protection against injury in about half of the cases. Safety in trucks and buses could be improved by the introduction of a deformative zone in front of the occupants.

Front designs of cab-over vehicles should be changed and the use of seat belts in trucks and buses should be made compulsory. Passive seat belts, knee bars and air bags are interesting alternatives and additions to manual seat belts for commercial drivers.

Key words: Occupational, accident, injury, prevention, personal safety equipment, emergency action, commercial vehicles.
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To Jan Thorson
who along the way
has become so much more
than a senior colleague
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This thesis is based upon the following publications, which will be referred to by their Roman numerals:


ABSTRACT

An analysis of the circumstances preceding severe occupational injuries as a consequence of impacts has shown that well-known risks are of great importance in 75 per cent of the cases. This indicates that the subjective cause "neglect" is common. The negligence is distributed to the same extent among employers as among employees. Negligence by the employers was defined as obvious violations according to the Law of Workers' Safety or Regulations issued by The National Board of Occupational Health and Safety. Negligence by employees was defined as actions against specific orders or common sense.

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Front designs of cab-over vehicles should be changed and the use of seat belts in trucks and buses should be made compulsory. Passive seat belts, knee bars and air bags are interesting alternatives and additions to manual seat belts for commercial drivers.

Key words: Occupational, accident, injury, prevention, personal safety equipment, emergency action, commercial vehicles.
INTRODUCTION

Every year approximately 110 000 occupational accidents are registered with The National Board of Occupational Health and Safety. About 2 000 lead to permanent medical disablement - 150 are fatal. The number of serious occupational injuries by impacts is gradually diminishing (Jarl, Thorson 1978, Riksförsäkringsverket 1976, Statistics Sweden Sweden 1983).

The first trials to explain accidents were focused on individual behaviour, in other words concentrating on psychological causes. Occupational accidents were regarded as expressions of e.g. the tendency to self destruction (Arbetarskyddsfonden 1973). One theory which gave rise to great interest concerned the concept of "accident proneness" (Greenwood and Woods 1919, Newbold 1926). By this expression individuals with a tendency to suffer injuries by accidents came into focus. The accident proneness concept has been abandoned as a scientifically insufficient model of explanation. It has been shown that occasional events in a changing environment and the physical fitness of the persons concerned are more important than other variables (Surry 1969). The concept is furthermore often difficult to use from a prophylactic point of view, as it is mainly a concept concerning the effect of accidents. To suffer several injuries is of course not the same thing, conceptually, as to cause several injuries (Thorson 1973).

The causal concept regarding occupational accidents has been widened to embrace the whole human-environment-machine system (Surry 1969, Arbetarskyddsfonden 1973). Epidemiology has become a field of science which has been very supportive in the type of research where different kinds of background variables are the basis of causal analysis (Hagbergh 1969, Fredin et al 1974, 1975). Epidemiological techniques may also be used to evaluate the benefits of different methods of intervention in the field of injuries caused by impacts (Robertson 1983, Schelp 1987, Jansson 1988 a).
Within the Swedish Work Environment Fund an epidemiological model for accident research has been worked out (Arbetarskyddsfonden 1973). Svanström et al have subsequently developed this method (Andersson et al 1975). The model is based on a stepwise analysis of the injurious events which together lead up to the accident. It includes all types of "disturbances", from small ones in the process of work, via near accidents to accidents with personal injuries of different severity. In this model every episode has the same importance, without regard to the consequences for the persons involved.

The basis for this approach is to be found i.a. in the work of Heinrich (1959). He states that for every accident with a severe personal injury there are 300 slighter injuries or near accidents. By studying these events it should be possible to prevent accidents. The question is, however, whether we collect a lot of information which is not very useful in this way. It is of course not only random events that decide whether a worker will have a small scar or be killed in an accident at his place of work. Different types of occupational circumstances also contribute differently and with different probabilities to the risk of serious injuries (Baker 1972).

Since allocation of resources entails a choice among priorities it is natural that our knowledge about the most severe accidents should be increased first, that is those resulting in fatalities or permanent disability (Pearson 1969).

In the preventive work which is carried out within the framework of the health care in the industry the same attitude should be guiding the choice of priorities. Risks of serious injuries should be examined as a matter of first order, which means that serious accidents should be regarded as the most interesting ones (cf Steinbeck et al 1982). In the daily preventive work at the place of work, however, near accidents make a good starting point for preventive measures. In towns and local districts injury registration can play an im-

The organization of the work is obviously important as a causal factor in serious accidents. The change from different types of piecework pay to periodical salaries (monthly wages) has contributed to a decreasing frequency of serious occupational injuries (Kronlund et al 1973, Socialmedicinsk Tidskrift 1975). Another factor of importance is the attitude of the employers to preventive measures at the work places (Lindström, Sundström-Frisk 1975, Jansson 1988 a). It is also possible that the nowadays more powerful position of the employees in the planning of the work and initiation of preventive activities has contributed to the reduction of the frequency and severity of injuries. An example of this is the right of the "skyddsombud" to stop a potentially dangerous work process until the labour inspectorate has established whether health risks of a serious nature are at hand (Landsorganisationen 1976).

Technically speaking the cause of many accidents seem to be relatively simple (Fredin et al 1974, Borgström, Thorson 1975, Borgström et al 1981). However, in the background a clearcut deviation from stated rules can very often be seen - either by the worker himself or on the part of the employer. This condition is especially important if the standards from The National Board of Occupational Health and Safety based on the law on occupational environment are concerned.

In addition to the above statements there are also often insufficiencies in working methods or in technical equipment. A machine might be equipped with "necessary protective devices" and still be dangerous to work with. This emphasizes the basic, general approach of adapting the environment in its broadest sense to man. This is also the way that leading research in the area of injury mitigation is carried out (Baker et al 1984).
The risk of injury

From a medical point of view occupational health and safety activities should be concentrated on the prevention or mitigation of occupational injuries.

The consequence of this is that very often it is more efficient to direct measures to the quality, i.e. severity, of injuries rather than the quantity, i.e. number, of injuries. Personal injuries may be regarded as the result of undesired energy transfers from the environment to human beings, compare the result of harmful energy transfers. It is possible to diminish the risk of injury by modifying the effects of the energy released, so that it will not cause an injury. In certain cases prevention of uncontrollable energy release, that is prevention of personal injuries, may be possible. In cases where this seems to be impossible, however, very often there remain ways of reducing the severity of injuries. The harmful energy may, after certain measures, be modified in such a way that the injurious effects will be less serious. Injury minimization is consequently possible even if the problem to establish an effective prevention seems to be difficult.

The definition of injury cause which is used here, release of energy, was proposed by Gibson (1961). An application of this basic causal theory is the ten strategies for the reduction of injuries which were developed by William Haddon Jr (1970) and Haddon and Baker (1981). They are presented here; see Table 1.

The approach according to Haddon is constructed in such a way that all possibilities to fruitful measures may be analyzed. The application concerns the objective - or external - circumstances irrespective of types of injuries and forms of energy causing them.
Table 1
Minimization of injuries according to Haddon and Baker (1981)

1. Preventing the accumulation of potentially injurious agents.
2. Reducing the amounts of potentially injurious agents.
3. Preventing the inappropriate release of potentially injurious agents.
4. Modifying the release of the agent.
5. Separating people in time and/or space from potentially injurious agents.
6. Separation by physical barriers.
7. Modifying surfaces and basic structures.
8. Increasing resistance to impacts.
9. Counter-act damage already done.
10. Stabilizing, repairing and rehabilitating the injured.

Parallel to mechanisms of injury (the objective causes) it is also beneficial to find causes of injury related to human behaviour (the subjective causes). The objective causes are related to the type of energy which is released in an uncontrolled manner towards the person exposed to it. The second type of cause, the subjective one, is defined according to the degree of intent to cause the injury. Negligence and intentional injuries are of special interest from the point of view of legal action when injuries to other people than those causing the injuries are concerned. As to self-inflicted injuries interesting possibilities, not only psychiatric ones, exist (Beskow 1987, Thorson et al 1988). Intentional injuries as well as injuries caused by negligence or accidents are also caused by objective circumstances which sometimes are more easily controlled than the subjective ones, cf Hassall and Trethowan (1972). Both causes co-exist although one or the other may be emphasized for practical and/or political reasons. Thus any injury problem could be approached in two supplementary ways.
AIMS OF THE THESIS

Information of objective as well as subjective causes of injuries has a strong bearing on the effectiveness of injury minimizing. Consequently, we should be anxious to learn whether already known risks still cause injuries. Well-known causes of injury imply that the consequences should be regarded as the result of negligence and not as "accidents". If this condition is common in connection with serious injuries it is of central importance to know the relation between objective and subjective causes. This will make the injury minimizing work as efficient as possible.

This does not mean that the best means to reduce effects of negligence are measures aimed at changing the behaviour of those exposed to or responsible for environmental risks. Environmental changes should be considered means of first order interest. However, if negligence is at hand the occasional benefit of pedagogic activities should be considered with great caution; see Robertson (1983).

The thesis has the following two general aims:
1. To examine whether already well-known risks of injury are of great or little importance as causes of serious injuries in occupational accidents; see Paper I.
2. To investigate whether serious injuries caused by occupational accidents might be mitigated using measures to prevent injuries and harm according to Haddon (Table 1); see Papers II-V.

Papers II and III mainly concern the potential effect of an increased use of personal protective equipment and an optimizing of the rescuing of those injured. They also evaluate methods to reduce injuries.

The main aim of Papers IV and V is to find and quantify vehicle-related (objective) causes of traffic injuries among drivers and other occupants of trucks and buses. Another aim of these Papers is to suggest further improvements concerning occupants' safety in commercial vehicles.
MATERIAL

Paper I

In order to investigate the importance of well-known risks (subjective causes) according to the first aim documentation of circumstances concerning fatal injuries from 1973, 201 cases, was used. From The National Board of Social Insurance (Riksförsäkringsverket (Rfv)) basic information was drawn from documents on those killed in occupational accidents that year. The records were supplemented by material from The National Board of Occupational Health and Safety, The Labour Inspectorate, The Inspection of Electrical Equipment and Police investigations. The main source of information (Rfv) supplied us with 180 cases. The rest of the cases were obtained from the other sources mentioned in the text. During 1973 one-man companies were not included in the general insurance system for occupational injuries.

One material consisting of 114 so called "noticable" cases were also investigated within the framework of Paper I. These cases had been considered to be of special importance by the Labour inspectorate because of the severity of the injuries or because of other noticable circumstances concerning the injuries. They were obtained from half of the Labour inspectorate districts in Sweden and consisted of all cases registered at these inspectorates in 1973 and, to a smaller extent, in 1974.

Papers II and III

The studies concerning the importance of personal preventive measures and rescuing concerned fatalities as well as permanently disabled cases.

In Paper II thus the same fatalities were used as in the study of occupational accidents according to Paper I. In Paper II, however, three cases known to us only from the police records were not included. They were not found until the work according to Paper II was finished.
The important circumstances with regard to nonfatal injuries (Paper III) were studied by means of a sample. Approximately every third case among injured employees with permanent (medical) disablement of at least 15 per cent (in 1973) was selected by random choice. The sample comprised 410 cases out of a population of 1275.

A pilot study of 42 randomly selected cases was devoted to persons who suffered less serious degrees of permanent disablement.

**Paper IV**

The basic material in this study was obtained directly from The National Board of Occupational Health and Safety (ISA). We started with all drivers and passengers of trucks and buses who suffered occupational traffic injuries in Sweden during the period 1979-1982, in total 1399 cases of injury. Only fatalities or injuries serious enough for sick-listing were included. When analyzing the mechanisms of injury the material was focused on a sample of truck and bus drivers injured or on the sick-list for at least 30 days, in all 188 drivers.

**Paper V**

This study was based on three samples from the official statistics on occupational injuries run by The National Board of Occupational Health and Safety. The first sample consisted of a random half of all workers who contracted occupational traffic injuries in trucks and buses in 1981 and 1982, and who had been on the sick-list for at least 30 days. This sample consisted of 110 cases. Injured truck and bus occupants were all interviewed by one of the authors (T J). If the injured person could not be reached by telephone a postal questionnaire was used.

The second sample consisted of all fatal occupational injuries to truck and bus occupants (mostly drivers) in Sweden in 1979-1983, totally 45 cases. Supplementary
material to this part of the study was received primarily from police investigations, death certificates and autopsy and hospital records. This information was collected by one of the authors (T J).

A third sample consisted of all cases of traffic injury to truck and bus occupants employed by the Swedish state in 1981 to 1983, 76 cases. In this sample all cases were included irrespective of severity of injuries. All cases were interviewed by one of the authors (A Ö).
METHODS

Paper I

In order to decide whether a risk was well-known the circumstantial facts about injurious events were compared to what was prescribed according to the standards based on the workers protection laws. Besides the Work Environment Law there was the declaration of Workers' Safety (Arbetarskyddskungörelsen) and the standards, predominantly those from The National Board of Occupational Health and Safety. Information about the accidents was registered on special forms, one for every case of injury. Judgements were performed by the three authors separately. The conclusions were then discussed by the authors. If the pertinent risk situations were classified as well-known the problems of responsibility had to be dealt with: Had anybody involved shown negligence according to existing rules?

"Negligence" on the part of employers was regarded as present if a deviation from the standards according to The Board of Occupational Health and Safety could be demonstrated. "Negligence" on the part of employees was assumed when there was an explicit standard for equipment or methods and when this was well-known and yet overlooked by the worker himself.

The methods to assess whether negligence had been at hand were supplemented by legal investigations of serious cases of "accidental" occupational injuries (Borgström, Thorson 1975, Borgström et al 1981).

Papers II and III

The basic method for the analysis of personal protective equipment and the rescuing of the injured included the description and classification of the injuries according to the types of energy that were involved. This was done in order to get a systematic and common judgement of the physical conditions in the cases. In Paper II the clear statements in the autopsy protocols facilitated the evaluation. In Paper III the selected persons were
interviewed by telephone or by a mailed questionnaire. All interviews were carried out by the same person, one of the authors (M 0). The interviews were based on the descriptions of the "accidents" that had already been sent in to the Rfv. The type and direction of the violence were compared with the injuries observed, and it was estimated whether personal safety devices might have been applicable in every single case considering their function. To enable us to state that the personal protective equipment could supply the appropriate function two criteria had to be fulfilled:

a) the protection must be sufficient and proportional to the violence in terms of magnitude and type.

b) the protection must be reasonable in terms of not being a hindrance in the work process and in terms of risk exposure, i.e. the probability of a serious injury in a certain work situation.

As to the rescuing of injured workers the time from the moment of injury until the situation of the injured person was observed was a starting point for our judgement. This time was decided on the basis of information in records from the place of work, the police and from hospitals. Also descriptions of health activities, e.g. causes of delays and other insufficiencies were based upon information in the same material. Complementary information on the permanent disablement was collected in interviews with the injured workers.

**Paper IV**

In the study of occupational traffic injuries in vehicles according to Paper IV we had full access to all the data within the ISA system. This made it easy to produce the cross-tabulations that were of interest. When it came to an analysis of injury mechanisms the data alone were insufficient. To get a detailed view of what had happened at the site of injury we had to read the reports that had been sent to The National Board of Occupational Health and Safety. The drop-outs from these 188 cases were many - 82 cases. They were drop-outs
mainly because the information was not detailed enough to allow analysis. This fact actually was one of the reasons behind Paper V. Still, for the remaining 106 cases the information was valuable (and possibly truthful since there is no financial consequence built in to the question "Who caused the injury?"). The notes had to be signed by both the employer and the employee. Some of the most typical incidents have been used as illustrations (case reports) in the Paper.

**Paper V**

Special forms were constructed to make it easier to document the results of the interviews. The information about courses of events, damages to vehicles and injuries to persons were put in relation to the information which is stored in the reports on occupational injuries that the ISA material is based on. Further, an evaluation of the mechanisms of injury was done and the cases were classified according to objective causes of injury concentrating on safety systems and the construction of the cabins. In the case of multiple injuries more than one cause were generally presented.

The methods used for the study of fatalities in occupational traffic are similar to the one above. The most important difference is that the basic material was in written form. In some cases complementary information was added to the material by telephone interviews with investigating policemen or with the employer.

**Validity**

As to the validity of the data in the studies the observations in Papers I, III, IV and V were subject to evaluation by the authors separately before each case was decided on. This method was used by Fredin et al (1970, 1972) and Thorson (1975). In Paper II there was no co-author; cf page 21.
RESULTS

RISK CONTROL (I)

Already well-known risks were important for the occurrence of serious occupational injuries according to (I). In the analysis of fatal injuries subjective causes, by right labelled as neglect, predominated: 75 per cent of the fatal occupational accidents in Sweden in 1973 were heavily influenced by negligence, the responsibility for which was evenly split between employers and employees. By "negligence" is meant that the injuries were brought about under circumstances which included deviation from applicable standards or commonly accepted working methods.

Insufficiencies of established techniques and methods used, were "main" causes of a fifth of the injuries. Neglect was thus not an obvious cause of these injuries. The few cases left were caused by disease or by external circumstances of a new or in other respects forgiveable quality. These few cases were rightly named "accidents". Nobody was reasonably responsible for them. In a few cases the investigative material was not sufficient for the above causal analysis.

The analysis of the 114 non-fatal accidents shows a similar distribution of causal categories. The result of both studies supports the assumption that well-known risks are quite important: half of the non-fatal cases and one third of the fatalities were injured because of insufficient safety measures for which employers were responsible. Almost a quarter of the injured workers had caused the injuries themselves by acting against better knowledge, not by distraction. About one fifth of the events were sufficiently explained by technical or organizational circumstances.

Important differences between different occupational activities were observed. As to mining, traditional industrial work and construction work, the majority had been injured as a consequence of insufficient safety measures by the employers. Injuries in the fields of
service and repair, farming and forestry were caused by circumstances for which the injured workers mainly were responsible themselves. These workers had been placed in a situation where they had a greater responsibility for their own health than most other groups of workers. Compare for example the standards for forestry (Arbetarskyddsstyrelsen 1972). Injuries which occurred during land transports were more often than other injuries caused by other drivers or by the injured worker himself. Technical insufficiencies where questions of responsibility are of a less interest from a prophylactic point of view were especially important in storing, mining, stone industry and aviation.

INJURY MITIGATION BY MEANS OF PERSONAL SAFETY EQUIPMENT (II AND III)

The predominating objective cause in the study of fatal cases was mechanical violence with the sub-groups horizontal violence, e.g. collisions, vertical violence i.e. falls of objects or persons, and combined mechanical violence (contusions and cuts). The other groups were thermal energy, explosions, fire and burns, electrical energy and a group with injuries of different kinds of violence where suffocation often resulted.

Fatalities

The effect of personal protective equipment on the risk of fatal injury was estimated within Paper II and the benefit of an increased use of such equipment was examined. Personal protective equipment may, according to Haddon's ten strategies, limit the effects of injurious agents in some principally different ways (see Table I, page 13). A safety belt or a life line (used for example during work on roofs) illustrates point number 3 in the table ("Preventing inappropriate release of the agent"). A helmet, on the other hand, functions according to point 6 ("Separation by physical barriers") as do flame-proof clothes.

For a majority of the fatalities the amount and quality of the energy of the impacts were such that personal
protective equipment would not have meant any significant reduction in the threat to the workers' lives. However, for about one third of the material of fatalities, 73 cases, personal protective equipment would have meant such a reduction. No protection was used in 48 of these cases. In 11 of these 73 cases applicable personal protective equipment was used. However, other circumstances such as inappropriate emergency procedures or medical complications contributed to the fatal outcome in these events. As to 14 cases, finally, it has not been possible to establish whether personal protective equipment was used at the moment of injury.

The most frequent group where personal protection was regarded useful is the one involving falls. Half of these workers were not wearing a life line (falls from high heights) or a helmet (falls from low or moderate heights) in cases where these might have been of crucial importance. Another important group are those injured by horizontal violence. Increased use of seat belts in passenger cars as well as commercial vehicles including buses should contribute to a reduction of the number of fatalities.

Protective clothes against corroding liquids or flame-proof clothes, gloves and shoes insulated against electricity and life vests when working near or above water are further examples of personal protective equipment with life-saving functions. However, from the fact that protective measures such as these have been judged applicable it does not necessarily follow that they are the best method to solve the problem of safety in the working situations described; cf the presentation of methods to achieve injury minimization (Table I).

Disabling injuries

To investigate the possible injury mitigating effect of an increased use of personal safety equipment 410 occupational accidents with long-term injuries were analysed. Occupational work in factories was the most common activity at the moment of injury; "service" (repairing) and construction work followed in order of occurrence.
The disabling cases displayed the same distribution in terms of types of violence as the fatalities in the preceding Paper (II). Mechanical energy is still more prominent in the disabled cases than in the fatalities group. About 97 per cent of the injuries were attributed to the (objective) causal factor "mechanical energy".

From this investigation (III) it is clear that personal protective equipment was an applicable protective method in a quarter of the injurious events. As to a third of these cases such safety equipment had also been used and consequently it had reduced the severity of the injuries. As to "mechanical energy, horizontal violence" the number of applicable and not applicable cases were roughly the same, half of each. The applicable cases were of two kinds: collisions where a seat belt could have increased safety and, secondly, mechanical eye protection. A pair of protective glasses might have saved the vision of the exposed eye. As to falling objects protective helmets should be mentioned. As to people falling with resulting disability most of the cases resulted from tripping or other falls on the same level. In such cases personal protective equipment is very seldom applicable and thus was not used. In the manufacturing industry, jamming and cuts were most common. Cuts, e.g. in the food-production industry, might be prevented by protective gloves (Kullman, Larsson 1985). However, in a few cases protective gloves contributed to increasing the risk of a serious injury as a glove was caught in a moving part of a machine and the hand was seriously jammed. This has also been described by Kullman and Larsson (1985).

\textbf{INJURY MITIGATION BY MEANS OF RESCUE AND CARETAKING (II AND III)}

In Papers II and III analyses of the post-injury events were documented. This is related to the Haddon strategies number 9 and 10; see Table I, page 13.
The survival times for the workers injured varied strongly. Just less than half of the accidents resulted in immediate fatalities. In one fifth of the cases death occurred within 10 minutes. Four of the injured workers survived for more than one month after the moments of injury. In 34 cases (17%) fatalities would have been avoided with a high probability if rescuing and treatment had been optimal.

In 15 cases (8%) the circumstances were such that the injured person was not immediately killed but because he had been working alone the situation was not observed in time to save his life. The most common cause of death in this group was suffocation.

In seven cases the injured person was not saved in spite of the fact that immediate rescuing procedures were commenced by his working fellows. In these cases planning and training for a serious accident were bad. Lack of suitable equipment made rescuing difficult, and help did not reach the injured person in time to save his life.

Improved first-aid activities, according to this study, would have been effective to save some lives. Thus, incompetence in handling the emergency situation on the site of the injury was a contributing cause of the fatal outcome in three cases. An example of this is a case where bandaging of an abundantly bleeding wound was neglected.

Added to the risk of suffering a serious injury is the risk of life threatening complications such as septicaemia, embolisation of lung blood vessels, arterial bleeding after intubation and other complications connected to or in spite of hospital treatment. Nine cases of medical complications were found in this material.
Disabling injuries

In about every tenth case there had been circumstances after the injury that resulted in a negative outcome of the injury. One such important circumstance that could be improved is the rescuing on the site of the injury (21 cases, 5%). Other important points are working alone (cf fatalities) and minimization of the seriousness of the injury by the injured person himself, a circumstance which delayed adequate treatment ("patient's delay").

The treatment during ambulance transports is also an important post-injury circumstance. This part of the problem cannot, however, be thoroughly examined in this kind of study. The information from ambulance personnel, the training of the personnel and the equipment of the ambulances may be improved; examples from the investigated materials illustrate circumstances previously recorded by other authors (Sjöstrand, Neldin 1979). For example a seriously injured worker had to walk to the waiting ambulance because one of the ambulance men suffered from an aching back.

INJURY MINIMIZATION IN TRUCKS AND BUSES (IV AND V)

Vehicle-related causes of injury

Injuries to occupants of trucks and buses during work in the traffic were selected as an important injury group. The investigations were concentrated on vehicle-related mechanisms of injury and evaluation of the possible effects of safety belts on the outcome of the injurious events. These measures concern strategies 3, 4, 6 and 7 according to Haddon (page 13).

Collisions were common in both studies. The occurrence of this circumstance was associated with injury severity in Paper V. In the least severe injury group (state employees) about one third of the injuries were due to collisions. Among severe non-fatal injury cases the corresponding figure was just over 50 per cent. As to fatalities collisions with another vehicle or a fixed object were crucial events in two thirds of the cases.
The frequency of overturnings also co-varied with the severity of the injuries. Thus the rate among state employees was 18 per cent, among severe injury cases 27 per cent and among fatal cases 33 per cent respectively.

Deformation of cabins was a frequent correlate to personal injuries according to both studies (IV and V). 40 per cent of the drivers who were injured but survived were injured in an event including deformation. Among the fatalities the corresponding frequency was 50 per cent.

Risks of injuries related to deformation of cabins were observed to be of special importance for those truck and bus occupants travelling with cab-over models of vehicles, i.e. vehicles which have a very short frontal zone of deformation compared to vehicles equipped with hoods. In the group of severely not fatally injured cases it was possible to show an increased severity of injury when riding in a cab-over type vehicle. Also the pattern of injuries was dependent on the cab type and according to the Maximum Abbreviated Injury Scale (MAIS) standards more life threatening in the cab-over models (American Association for Automotive Medicine 1985).

Seat belts should have reduced the frequency of injuries and the severity of them in almost half of the examined injurious events. Among surviving cases, however, about 10 per cent of the events would probably have been more injurious had a safety belt been used. These cases occurred in cab-over vehicles which were heavily deformed, while the drivers were ejected.

Ejection of drivers also varied with the severity of the injuries. Thus, among state employees (all injuries regardless of severity) seven per cent of the cases were ejected, in the more severe injury group the frequency was 12 per cent and in the fatal group ejection occurred in every third case.

Other injurious details studied in Paper V are steering wheels, glass of windshields and side windows, knee
bars (bolsters), absence of headrests in connection with rear collisions and loose objects within the cabins.

Too heavy or improper placing and fastening of cargo on trucks was the causative factor in nine per cent of the fatalities.

In eight per cent of the fatalities analysis of blood alcohol showed significant values. This figure, although based on a small sample, is lower than in an average traffic sample in Sweden (Valverius et al 1982).
These studies concern among other things the question whether serious occupational injuries by "accidents" have been caused by already well-known risks. The result of Paper I confirms the assumption that for a long time well-known risks are crucial for the occurrence of serious occupational injuries. Against the background of dangerous occupational environmental circumstances, in contrast to what could be expected according to the standards from The National Board of Occupational Health and Safety, it is natural to look upon these risks as the result of negligence (in contrast to the vague word "accident") in a good part of the cases.

It is striking that the word "accidents", which should rightly be used for injuries caused by circumstances which are not possibly anticipated, to a significant extent has been shown to cover quite another type of reality. Standards from The National Board of Occupational Health and Safety regarding important measures to keep risks under sufficient control were often not applied where they would have been relevant. This is a condition which especially concerns the responsibility of the employers. Furthermore there was negligence on the part of the employees themselves in choosing a method of work which was not traditionally accepted or in other ways putting the safety standards aside. Together these two types of negligence occurred in connection with more than half of the fatal cases studied according to Paper I. Those injurious events which rightly should be labelled "accidents" were a minority; only a few cases came up suddenly and without possibility to be foreseen and without any responsibility reasonably to be put on any of the persons concerned.

The word "accident" should be used restrictively. It is of little value when it is used without distinction, thus including injuries caused by negligence as well as accidents proper.
According to Paper I it was confirmed that well-known risks have a great importance for the occurrence of serious occupational injuries. The hypothesis that the subjective cause negligence is important was also supported. Continued research according to the experiences of Paper I was influenced by this very result (Borgström et al. 1981). A reform of the criminal law involving an increased duty for prosecution of work environment crimes became effective from July 1st, 1980 (SFS 1980:107).

The results of Paper I stress the fact that there are serious insufficiencies in the organization of occupational risk prevention and in the responsibility in the companies. Aminoff and Lindström (1981) have suggested against the same background that the responsibility for preventive measures in the working environment in the companies should be more emphasized and that it should be more clearly related to the production line. Economic benefits of a good working environment should be of importance in strengthening the activities to make the preventive work effective, primarily to minimize the number of serious injuries. A step-back to the principles of the former insurance system for occupational injuries in Sweden where injury minimization payed off in a lowering of the annual fee for the insurance might be considered (Jönsson, Lyttkens 1981).

As far as employees are concerned an increased consciousness of risks and better information on how to avoid risks seem to be very important; cf Jansson (1988 a). However, Robertson (1983) clearly pointed out the limitations of training as a method of prevention. Early measures against alcohol addiction is also a strategy which could reduce the number of injuries (Aronsson 1976). Furthermore, reducing safety in order to gain time should be eliminated by selection of techniques that make it impossible to perform the work without well-functioning equipment. The most attractive solution is, of course, to find safety devices that facilitate work performance.
REDUCTION OF SEVERITY OF INJURIES

If injuries cannot be totally eliminated the second best alternative is to try to reduce the consequences of the injurious events. An applicable way to identify risks and to find solutions to avoid injuries is to use the Haddon strategies based on the concept of energy release in relation to human tolerance; see Table I, page 13 and Björnstig (1985). This approach is also suitable for problems already well-known as causes of injury, and in addition, which goes without saying, it should also be applied when new work sites are being planned (Harms-Ringdahl 1982). The Papers II-III illustrate that mitigation of injuries is possible by the application of already existing knowledge. The benefit of applying this knowledge should be very important with regard to reduction of severity of injuries.

In Papers II and III the benefits of an increased use of personal protective equipment are demonstrated. Of course elimination of risks should be given priority as a matter of principle. However, until such solutions are applied to the production process, personal protective equipment may be a realistic alternative worth considering; cf Reigstad (1978). One of the main results of these studies, however, is that the impacts in a majority of the events are so violent that personal protective equipment is not applicable.

Considerable medical advantages could be the result of a better preparedness at the work station as far as rescue is concerned. The danger of working alone is emphasized by cases in these studies.

As to post-injury circumstances promising experience from Norway with increased use of helicopter transports in traffic injuries are especially noteworthy (Buxrud 1984). Ambulance helicopters have also been tried in Sweden (Brismar et al 1986).

The analysis of serious injuries in the traffic environment (Papers IV and V) also supports the fact that
the use of personal protective equipment such as seat belts in commercial vehicles is well motivated. These studies also show a number of other vehicle-related causes of injuries where changes of design probably would contribute to mitigation of injuries. The causality between cab design and an aggravated injury pattern is logical - however there is a need for an experimental verification of this assumption. Causality thus was not sufficiently confirmed epidemiologically in these studies due to the lack of control of such factors as speed and exposure time versus truck cabin design.

Circumstances important to injury severity in train/car and train/pedestrian collisions were analysed to find recommendations for train front designs (Kulmala, Thorson 1986). It might also be beneficial for commercial drivers if the intentions of the Work Environment Law could be enforced behind the steering-wheel.

Changes in the design of commercial vehicles are difficult to implement because of the fact that the market for these vehicles is international. However, safety should be a selling argument also in the case of trucks and buses. It is also of interest that some of the changes which are recommended in Papers IV and V, e.g. zones of deformation on trucks and buses might be designed so that they would benefit any road user hit by heavy vehicles.

In the studies that form the basis of this thesis the statistics on occupational injuries have also been considered. Papers I-III showed insufficiencies as to the completeness and thus usefulness of the formerly existing occupational injury statistics in Sweden. The completeness of the current occupational injury statistics was also studied by Schelp et al (1979), Berg and Malmqvist (1983), Jansson and Svanström (1988) and Backlund et al (1988). These studies indicate that an important drop-out problem still exists. The amount of unreported occupational injuries to The National Board of Occupational Health and Safety is considerable. Among the drop-outs less serious injuries predominate, i.e. injuries resulting in the absence from work for not more than one
week; cf Carlsson (1984). Substantial reduction of the drop-out may be achieved by supplementing the official statistics by data from hospital and private insurance (Backlund et al 1988).

In Papers IV and V it is pointed out that it is desirable to achieve a higher quality in the statistics on occupational injuries in the traffic. The statistics should cover for instance seat belt use, vehicle fronts and traffic exposure. Improvements in these respects would make it possible to evaluate the efficacy of preventive measures. Of course several of these problems are international, especially those related to vehicle construction. In this respect it is important that the risk exposure in connection with heavy vehicles is furthermore studied.
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