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# Accidents leading to over-exertion back injuries among nursing personnel

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# List of original papers

This thesis is based on the following papers, which will be referred to by their Roman numerals.

- I. Engkvist, I-L., Hagberg, M., Lindén, A., Malker B. Over-exertion back accidents among nurses' aides in Sweden. *Safety Science*, 15, 97-108, 1992.
- II. Engkvist, I-L., Hagberg, M., Wigaeus Hjelm, E., Menckel, E., Ekenvall, L., PROSA Study Group., Interview protocols and ergonomic checklist for analysing overexertion back accidents among nursing personnel. *Applied Ergonomics*, 26, 213-220, 1995.
- III. Engkvist, I-L., Hagberg, M., Wigaeus Hjelm, E., Menckel, E., Ekenvall, L., PROSA Study Group, Investigation of the accident processes preceding overexertion back injuries in nursing personnel. *Scandinavian Journal of Work and Environmental Health*, 24(5) 367-375, 1998.
- IV. Engkvist, I-L., Wigaeus Hjelm, E., Hagberg, M., Menckel, E., Ekenvall, L., Risk factors for reported overexertion back injuries among nursing personnel– a case-referent study Submitted for publication. *Epidemiology* (accepted with revisions).
- V. Engkvist, I-L., Kjellberg, A., Wigaeus Hjelm, E., Hagberg, M., Menckel, E., Ekenvall, L., Back injuries among nursing personnel-identification of work conditions with cluster analysis (Submitted).

# List of abbreviations

AIIR	Annual Injury Incidence Rate
CI	Confidence Interval
OR	Odds Ratio
RR	Relative Risk
95% CI	95% Confidence Interval

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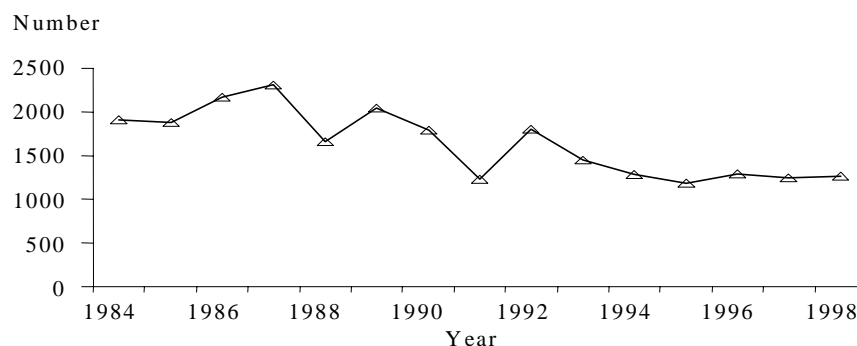
# Introduction

Accidents leading to over-exertion back injuries were observed to be a great problem among nursing personnel in Sweden during the 80's. During the period 1983 to 1986 13,000 assistant nurses reported an over-exertion injury. The body part most frequently injured was the back (Malker et al., 1989). Many other studies have shown that nursing personnel have a high prevalence of back pain and occupational back injuries compared to other occupational groups (Dehlin et al., 1976; Harber et al., 1985; Ljungberg et al., 1989).

Although there is a lower frequency of reported back injuries among nursing personnel today than during the peak in the 80's, the statistics show that the magnitude of the problem is still high and has been fairly constant during the last five years (Figure 1).

Injury reports provide the basis for statistics about accidents and the injuries they cause, but are seldom used to initiate preventive changes. Statistics on the incidence of accidents give some insight into the magnitude of the problem as it appears nationally, but little or no information about the causes of accidents or suggestions for preventive measures. One reason for this lack of information is that the data rely on reports from individuals who are unlikely to be trained in accident investigation (Troup, 1988). The information given in an accident report is therefore often inadequate, both for understanding the factors and events involved in the accident process, and as a basis for initiating preventive measures.

For a reported accident to have an impact on safety work, the injury report should not be the end product, but should rather serve to initiate an investigation of the accident process and be a way of collecting information useful for preventive strategies. It is only a careful investigation of the circumstances involved in the accident process that makes it possible to suggest preventive measures to avoid a risk situation, or to block a process once started.



**Figure 1.** Number of accidents leading to over-exertion back injuries reported by nursing personnel (registered general nurses and assistant nurses) during 1984-1998. (Personnel communication A Lindén, National Board of Occupational Safety and Health, Sweden).

Work-related and individual risk and protective factors for back injuries among nursing personnel are still not completely understood. The pattern of concurrent risk and protective factors is even less known. Thus, there is limited scientific knowledge concerning effective preventive strategies.

Occupational injuries entail great costs (Bigos et al., 1991; Dempsey et al., 1997; Simpson, 1988; Spilling et al., 1986). For society they entail sick pay, medical care, insurance, sickness pension, etc. For the employer they lead to costs for sickness benefit, over-time, recruitment of new personnel, etc. For the individual worker they lead to loss of income as well as physical and mental suffering as a result of the injury.

In Sweden costs due to acute low back pain were calculated to 47,500 SEK (\$5,523) per patient. Of the total costs, 90% was indirect costs due to sick leave (Seferlis, 1999). NIOSH stated that work-related musculoskeletal disorders represent a major part of the costs of work-related illness in the United States. Back pain is by far the most prevalent and costly musculoskeletal disorder among U.S. industries today (Bernard, 1997). The mean cost was \$ 8 321 per case of compensable low-back pain during 1989 in the U.S., while the mean cost for other musculoskeletal disorders was \$4 074 (Webster et al., 1994).

With the aim of preventing injuries among nursing personnel, it is therefore of greatest importance to identify the factors involved in the accident process leading to an injury, and to identify the risk and protective factors and how they are connected. This is the main aim of the present thesis.

## **Anatomy of the back**

The spine is a very complex structure. It protects the spinal cord and provides mobility for the back. It also furnishes support for the upper portion of the body and transmits weight to the pelvis and lower extremities. The lumbar spine has a relatively wide range of motion since there are no ribs attached.

The vertebral column consists of 7 cervical, 12 thoracic and 5 lumbar vertebrae, attached to the sacrum, which is joined to the pelvis at the sacroiliac joints. The vertebrae consist of a body, cylindrically shaped at the front, the upper and lower surfaces of which are referred to as the end plates. The posterior part of the vertebrae consists of two transverse processes, two vertebral arches, two facet joints and one spinous process. The facet joints limit the motion between the vertebrae.

Between the vertebral bodies are intervertebral discs, which constitute a quarter of the total length of the spine. These discs consist of a viscous nucleus (nucleus pulposus) surrounded by collagen fibres (annulus fibrosus). They are attached diagonally in both directions and fixed to the vertebral end plates and thereby decrease the motion of the vertebrae during both bending and rotating. The discs can sustain high compressive loads, but are also very flexible during movements in the spine due to the viscous nucleus. During the day the discs lose some body fluid, which means that the body length decreases around 2 centimetres. During

the night this fluid is restored. The discs degenerate with increased age, which makes them less viscous, decreases their height and makes them more vulnerable due to the fact that they can sustain less load. Due to degeneration or a trauma the nucleus pulposus can be pressed through a rupture in the annulus fibrosus (disc hernia). The spinal cord or its nerves can thereby be affected by the pressure from the disc hernia. The nerves can also be affected by mechanical pressure from other tissues causing pain and/or neurological disturbances.

The motion between the vertebrae is also limited by the facet joints and the joint capsule. The spine is stabilised by several long ligaments and the load on the different ligaments depends on the posture and movements in the spine and the upper body. The ligaments consist of collagen fibres.

The muscles in the trunk stabilise the complex spine, keep an upright posture during sitting and standing and produce movements both with and within the trunk. The movements in the trunk are flexion, extension, lateral bending, rotation and combinations of these movements. The muscles in the trunk are placed in several layers. The largest muscle in the back is musculus erector spinae which extends from the pelvis to the base of the head and is most important as a stabiliser, but can also perform dorsal flexion and some rotation (Petrén, 1976). The weight of the upper part of the body loads the back. The load increases when bending forward or stretching out the arms. The load on the back also increases when lifting, carrying or pushing things

Back pain can have its origin in any of the tissues in the back. During a lift, an injury can occur in *e.g.* the muscles, ligaments or apophyseal joint capsules. However, it is difficult to establish pathological conditions for the back, which is why it is seldom known from which type of structure the back pain really emanates (Dempsey et al., 1997; Hansson, 1989). Therefore no attempt has been made in this thesis to investigate which structures in the back were injured during the reported occupational accident.

## **Back disorders**

Back disorders have been documented as a work-related problem in many industrial employee populations (Battié et al., 1991; Bigos et al., 1991; Frank et al., 1995). The origin of pain from the back is complex and the causality is multifactorial (Vingård et al., 1999).

In the literature regarding back disorders many different terms have been used, *e.g.* back injury, back disease, back pain, back pain disorder, low back pain. The terms are seldom defined, thereby complicating the interpretation of the results and the comparison between different studies. For example Bigos *et al.* (1991) stated that back disorders are commonly described as back injuries, whereas, *e.g.* ILO define an injury as a result of an accident (ILO, 1996). In the following the original terms in the articles are used.

### *Work-related risk factors*

*Physical exposure.* Lifting and carrying loads and frequent bending and twisting have been proved to be associated with back disorders (Burdorf et al., 1997). Flexion and lateral bending of the trunk, and bending and rotation of the trunk are considered as potential risk factors for low back pain and disorders (Vingård & Nachimson, 1999). Most often the work task consists of a combination of lifting and one or several of these movements. Lifting combined with twisting is considered to constitute a great risk of injury (Battié & Bigos, 1991; Kelsey et al., 1984; Troup, 1987). NIOSH state that there is strong evidence for low-back disorders being associated with work-related lifting and forceful movements. They also state that there is evidence for work-related awkward postures, as well as heavy physical work, being associated with low back disorders (Bernard, 1997).

It has been found that nursing personnel with longer service have more injuries due to accidents (Kumar, 1990; Owen et al., 1984; Stubbs et al., 1983), while studies in industry have found that persons with short experience usually have more accidents (Laflamme, 1992; Saari et al., 1981).

*Psychosocial exposure.* Psychosocial environment as a risk factor for back pain or back disorders has been investigated in several studies. Some studies have shown back disorders to be associated with a poor psychosocial environment (Bigos et al., 1991) while others have found no such relation (Feyer et al., 1992).

Assessment of the influence of psychosocial factors on back pain or reported injuries is difficult, as jobs with high physical demands often include a poor psychosocial environment (Vingård & Nachimson, 1999).

Bernard (Bernard, 1997) concludes that while the aetiological mechanisms are poorly understood, there is increasing evidence that psychosocial factors related to the job and work environment play a role in the development of work-related musculoskeletal disorders of the back.

### *Individual and life style related risk factors*

*Age.* The occurrence of low-back pain increases with increasing age up to about 50-60 years of age, after which there seems to be a decline (Dempsey et al., 1997). On the other hand injuries in the back due to accidents have been shown to be related to age, following a U-shaped curve (Laflamme, 1997; Laflamme et al., 1995). This finding may be explained by the lower bone mineral content among people aged 18-19 and among those over 50 years of age than among the middle-aged. This means that young and old people's lumbar motion segments can sustain a lower load than those of middle-aged people (Hansson, 1989; Hansson et al., 1986). Heavy lifts combined with rotated and flexed postures constitute major risks of injury if the disk has degenerated, and rotation injuries themselves are causes of degeneration (Troup, 1987).

*Gender.* Several studies have shown that the prevalence of low back disorders is somewhat higher for men than for women, whereas musculoskeletal disorders in the upper extremity seem to be more common among women (Kilbom et al.,

1998). However, in the interpretation of these sex differences it should be kept in mind that men and women often have different jobs or work tasks. In order to analyse the role played by biological differences, NIOSH therefore suggests that future studies should be conducted in occupational groups where men and women perform similar jobs (Kilbom & Messing, 1998).

*Heredity.* Although the etiopathogenesis of degenerative findings in the disc and their relation to pain are poorly understood, changes in the disc are suspected to underlie many back problems. Studies among identical twins show that this disc degeneration could only be explained to a smaller part by physical loading conditions or age. Familiar aggregation, the combined effect of genes and shared early environment, accounted for most of the variation in disc degeneration (Videman et al., 1999)

*Overweight.* Overweight has in some studies been found to increase the risk of back injury (Deyo et al., 1989; Heliövaara, 1987; Liira et al., 1996; Wohl et al., 1995). Other studies on the relation between weight and low-back injuries have, however, failed to find an association. According to Dempsey (1997) the effects of overweight may only be substantial for the most obese individuals.

*Smoking.* Smoking has been indicated as a risk factor for back injuries in some studies (Battié & Bigos, 1991; Dempsey et al., 1997; Leboeuf-Yde, 1998) especially among heavy smokers (Deyo & Bass, 1989). A clear physiological causal mechanism has not yet been demonstrated, although a number of hypotheses have been proposed (Dempsey et al., 1997). An association between smoking and coughing has been found, which might increase intradiscal pressure, leading to disc bulging and herniation (Frymoyer et al., 1983). Another explanation could be the effect of nicotine by reducing vertebral body blood flow and thus impairing discal metabolism and making the discs more sensitive to physical stress (Frymoyer et al., 1983).

Boshuizen *et al.* (1993) found differences in prevalence of back pain between smokers and non smokers for occupations with heavy jobs, but no consistent difference in other occupations. They also found that a number of confounding risk factors were linked with smoking, such as lower economic class, level of education and also occupational exposure to heavy work. Leboeuf (1999) concludes in her review that signs of causality between smoking and back pain were consistently evident only in a study with a very large sample ( $n > 30,000$ ).

*Physical training and fitness.* Nachemson has suggested that exercise may reduce the risk of back problems e.g. through positively affecting disc nutrition and subsequently disc degeneration, as well as counteracting osteoporosis and muscular atrophy, whereas inactivity may increase the risk (Nachemson, 1989). Higher strength and fitness have been shown to prevent back injuries among fire-fighters (Cady et al., 1979). Increased maximum oxygen uptake among fire-

fighters decreased the frequency of sick leave and reported back symptoms (Cady et al., 1985), while no protective effect for back symptoms was observed among employees with less physically demanding work (Battié, 1989). Other studies indicate that low physical fitness increases the risk of work-related low back symptoms among nursing personnel, and that physical training is important for the individual's well-being, for prevention and rehabilitation of musculoskeletal disorders (Gerdle et al., 1995; Gundewall et al., 1993). On the other hand, Lahad et al. (Lahad et al., 1994) concluded in their review that there is too limited evidence to recommend exercise to prevent pain in asymptomatic individuals.

#### *Nursing personnel - back disorders, risk and preventive factors*

Many studies show that nursing personnel have a relatively high prevalence of back pain and occupational back injuries compared to other occupational groups (Burdorf & Sorock, 1997; Dehlin et al., 1976; Harber et al., 1985; Ljungberg et al., 1989).

One study found that nurses had almost 30% more days of sick leave per year than the general population (Pheasant et al., 1992), although it has been shown that nurses often go to work despite back pain (Estry-Behar et al., 1990; Garg et al., 1992). Twelve per cent of nurses who were injured had their employment terminated on medical grounds as a result of the injury (Heap, 1987).

Several studies show that reported back injuries among nursing personnel are related to patient transfers (Buxdorf et al., 1997; Engels et al., 1996; Estry-Behar et al., 1990; Hignett, 1996; Jensen, 1990; Owen et al., 1991; Venning, 1987). An increased number of patient transfers increase the risk of back injuries (Buxdorf & Sorock, 1997; Estry-Behar et al., 1990; Smedley et al., 1995).

The most stressful patient handling tasks for nurses have been found to be transfers between bed and wheelchair, and toilet and wheelchair (Owen & Garg, 1991). Further, the incidence of low back problems among nurses may partly be explained by the pulling and turning of patients in bed, and the load on the torso resulting from such tasks (Gagnon et al., 1987). Ljungberg and Kilbom (1984) found that on average assistant nurses perform two lifts each per hour of 20 kg or more. Micro-fractures may occur with repeated lifts of 20 kg (Hansson et al., 1988).

*Training in patient transfer.* Training in patient transfer is often required to prevent injuries among nursing personnel (Yassi et al., 1995). The traditional approach to training in patient-handling techniques has shown little, or no, long-term preventive effect (Hignett, 1996; Hsiang et al., 1997; Stubbs et al., 1983). Proposed explanations for this failure have been that the technique taught did not decrease the physical load, or that the nurses did not adopt the technique in their work (Hignett, 1996). However, Videman *et al.* concluded that training in patient transfer technique may prevent injuries among nurses (Videman et al., 1989). Their study included more hours (40 hours) than has been described in other studies, which might explain some of the positive effects compared to others. It is

still not known which is the best technique for the nurse to transfer a patient manually. Neither is it known which is the best way to teach and train the nursing personnel, and how much time it requires, or how often the training should be repeated.

*Transfer devices.* There are different kinds of transfer devices to facilitate patient transfers for the nurses (Cowan, 1997). However, these devices are seldom used in practical work (Garg et al., 1992; Prezant et al., 1987). Studies have found nursing personnel to be reluctant to use transfer devices, since they could not understand how to use them, or they lack experience in their use (Bell, 1984; Owen, 1988).

### **Concepts and models in occupational accident research**

#### *The definition of accidents in the Occupational Injury Register*

In Sweden, all working persons are compulsorily insured against occupational injuries. The Work Injury Insurance Act of 1976 requires employers to report all occupational injuries on an injury form. The form is sent by the employer to the social insurance office with one copy to the Labour Inspectorate and one copy to the occupational health care unit serving the company. At the Labour Inspectorate specialised staff examine, codify and register the information given. Occupational injuries are divided into three groups, according to type of injury: occupational accidents, commuting accidents and occupational diseases. The criterion used for classification of “accident” is sudden onset of symptoms, closely related in time to a specific event. For the “disease” classification, symptoms should have appeared gradually and should not to be related to a certain event. Occupational accidents are registered only if they have led to absence for at least one day, or to a dental injury. All occupational diseases are registered. All information is collected in the Swedish Occupational Injury Register (ISA). (ISA, 1996).

#### *Varying views of the concepts accident and injury*

The literature concerning accidents shows variation in the use and definitions of the concepts *accident* and *injury* among researchers, This has also been pointed out by several authors (Andersson, 1996; Hagberg et al., 1997; Laflamme, 1990; Larsson, 1995). Epidemiological research takes diseases as its point of departure. For this reason, it naturally focuses on the injury and attempts, for descriptive or analytic purposes, to relate injuries statistically to various individual and environmental factors. In this view, the accident event itself is often reduced to a mere parenthesis between the injury and a variety of conceivable causal factors (Andersson, 1996). Hagberg (1997) emphasises that some of the confusion and controversy in occupational injury research may be attributed, in part, to the lack of clearly defined terms and concepts. Consensus definitions of injury terms and concepts are rare, perhaps due to the traditional epidemiological focus on chronic and infectious diseases.

The terms *accident* and *injury*, are often used interchangeably and there is increasing confusion concerning their implications (Andersson, 1991). It has even been proposed to use *injury* as a concept including both the accident (event) and the outcome (the injury) (Ozanne-Smith, 1995; Robertson, 1983). This impedes comparison of statistics and obstructs understanding of the literature.

Why are there such different opinions on the concepts of *accident* and *injury*? One explanation can be that investigation of the accident process is multidisciplinary territory (Larsson et al., 1993). Researchers and practitioners from different fields and disciplines have focused on different parts of this phenomenon depending on their profession and their specific interest. The variation in the use of the concepts reflects the differences in starting point, but also how the user defines the concept.

One contributing factor that might explain some of the confusion over the concepts of *accident* and *injury* is the short time, often just a second or less, between the accident and the injury. This means, when referring back to the occurrence of an accident (the event) or the onset of an injury (the outcome), that the *place*, the *time* and the *task* performed are identical. For example, a patient suddenly loses his/her balance during a transfer and the nurse tries to stop the patient from falling and thereby injures her back due to over-exertion. In this case the accident occurs during a patient transfer, but so does the onset of the injury. This does not mean that accident and injury are interchangeable. The term *accident* should be reserved for the event and the term *injury* for the outcome.

Some researchers have suggested avoiding the word *accident* as having connotations of randomness, referring to the Oxford Dictionary which includes in its definition of accident, unforeseen contingency, chance, and fortune (Hornby, 1989; Langley, 1988), also as having the connotations of inevitability and lack of apparent cause (Ozanne-Smith, 1995). These assertions have been questioned by Andersson (Andersson, 1996), and no one has so far suggested a synonym for accident, covering the same concept, which the other researchers in the area have accepted.

Accidents may be unwanted, but they are not or should not be unexpected (Waller, 1985). Random factors no doubt contribute to the factors and events leading to an accident, and it is therefore generally not possible to predict *when* an accident will occur. However, this randomness does not mean that it is impossible to analyse the accident process after the accident has occurred, and to explain how and why it happened. Even if some contributing factors will still remain unknown, it may be possible to eliminate the risk of future accidents of a similar type by eliminating a necessary condition for them (*e.g.*, by changing how the task is performed or automating a critical part of the work process).



### *Models for occupational accident processes*

Several models exist for investigating occupational accident processes.

However, according to Laflamme all accident models have three standpoints in common (Laflamme, 1990):

1. A distinction should be made between an injury and an accident.
2. There might be similar sequences of events in the genesis of accidents, these sequences being initiated by disturbances in the production flow or process.
3. Disturbances and accident sequences are influenced by factors related not only to the immediate working situation but also to work organisation, in a broader sense.

Kjellén *et al.* (1980) have suggested a model for analysis of accidents, the OARU model (Occupational Accident Research Unit). In this model a distinction is made between three phases in the *accident process*: two preinjury phases – *the initial* and *concluding phase*- followed by the *injury phase*, *i.e.* the pathogenic outcome of physical damage in a person (Figure 2) (Kjellen, 1983; Kjellen, 1996; Kjellen & Larsson, 1980). The *initial phase* starts when there are deviations from the planned or normal process. The *concluding phase* is characterised by loss of control and the ungoverned flow of energy. The *injury phase* starts when energies meet the human body and cause physical harm.

Initial Phase	Concluding phase	Injury phase
---------------	------------------	--------------

**Figure 2.** Sketch of the OARU-Model (Kjellen, 1996).

Injuries are the result of a culmination of a set of circumstances and pre-existing conditions which may best be understood as a chain of events (Ozanne-Smith, 1995). Haddon's matrix provides a conceptual framework, which schematically represents this chain of events. Haddon's model also consists of three phases: *pre-event*, *event* and *post-event* combined with the three factors human, vehicle (product) and environmental (Figure 3) (Robertson, 1983). Haddon (1970) has also developed ten basic strategies for injury prevention to apply in different phases and to the different factors in the matrix. Some recommended strategies are to separate in time or space, and to protect by a physical barrier between the hazard and that which is to be protected. The model has been particularly useful in determining appropriate points for intervention in order to prevent or alleviate injuries. The point of intervention is not necessarily early in the chain of events; it should be where the intervention is possible, or ideally where it will be most effective (Ozanne-Smith, 1995). Haddon (1970) remarks that the larger the

amounts of energy involved in relation to the resistance to damage of the structures at risk, the earlier in the countermeasure sequence the strategy must lie.

Regarding prevention, Gjerstland has introduced the concept of *primary*, *secondary* and *tertiary prevention* (Gjerstland, 1955). *Primary prevention* is given before the person meets the hazard *e.g.* use of vaccine. *Secondary prevention* is used to reduce the symptoms and *tertiary prevention* to rehabilitate the person. Ozanne-Smith notes that the three phases in Haddon's matrix are generally equated with primary (pre-event), secondary (event) and tertiary prevention (post-event) (Ozanne-Smith, 1995).

		Factors		
		Human	Vehicle	Environment
Phases	Pre-event			
	Event			
	Post-event			

**Figure 3.** Haddon's matrix (Ozanne-Smith, 1995).

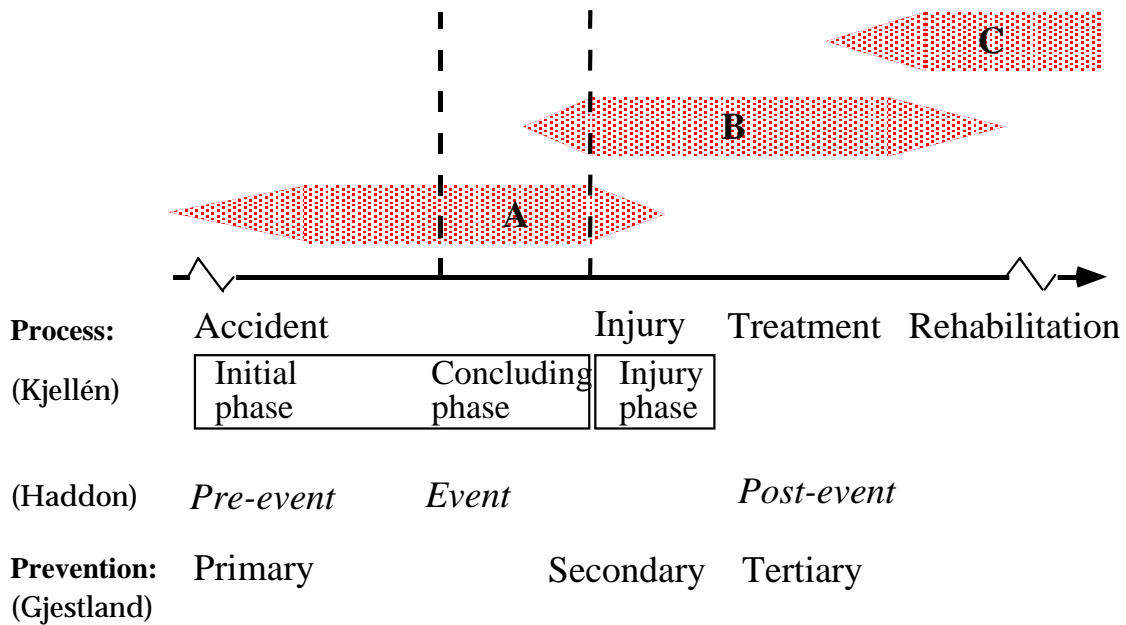
#### *A conceptual model for safety research*

The model in Figure 4 gives a schematic and general overview of how individuals with an interest in the safety research area differ in their focuses and approaches. The overview is intended to explain some of the variations in how the concepts are defined.

A): When the focus is on preventing the accident and thereby on finding the most efficient preventive measures, the factors contributing to the accident process will be carefully investigated. Less or no interest will then be spent on the outcome, the injury caused by the accident. This is often described in general terms, for example by indicating which part of the body was injured. The accident process has most often been seen as a technical, behavioural or social phenomenon, and has mostly been studied by the appropriate specialists (Backström, 1996; Kjellen, 1996; Laflamme, 1996; Larsson, 1990; Sundström-Frisk, 1996).

B): medical personnel have a professional focus on the injury and the injured person. In clinical work the injury will be carefully investigated and a diagnosis made, followed by treatment. The cause of the injury is also of interest, but will seldom be carefully investigated, and the causes will be stated in general terms, *e.g.* over-exertion, falls, trips and slips etc. In epidemiological studies the focus is also often on the injury and its consequences *e.g.* type of injury, incidence and sick leave (Jensen, 1986; Pines et al., 1985; Stout, 1992).

C): during rehabilitation there might be even less interest, or none at all, in the accident process, as the focus is now on the goal of getting the injured person back to work, or improving quality of life.



**Figure 4 .** Schematic overview of the approaches and primary foci of different researchers and occupational groups (A-C), depending on their specialities.

# Aims of the thesis

The overall aim of this thesis was to contribute to the knowledge of occupational accidents leading to over-exertion back injuries among nursing personnel, which can be used for developing effective preventive strategies.

*The specific aims were:*

- to investigate the occurrence of reported occupational over-exertion accidents leading to back injuries among female assistant nurses in Sweden during a two-year period and to identify factors and events, reported on the injury insurance form, related to these accidents (Study I).
  
- to develop a standardised instrument for systematic analyses of the accident process and to develop a screening tool for the physical environment that could be used quickly and easily to identify potential hazards for over-exertion accidents leading to back injuries among nursing personnel (Study II).
  
- analyse factors and events involved in the accident process preceding back injuries among nursing personnel (Study III).
  
- to identify and quantify work-related and non-work-related risk indicators for reported over-exertion back injuries among nursing personnel (Study IV).
  
- to identify the patterns of factors relevant for the risk of back injuries in work conditions typical for nursing personnel (Study V).
  
- to analyse how individual characteristics contribute to the risk situation for injuries in these work situations (Study V).

# Subjects and methods

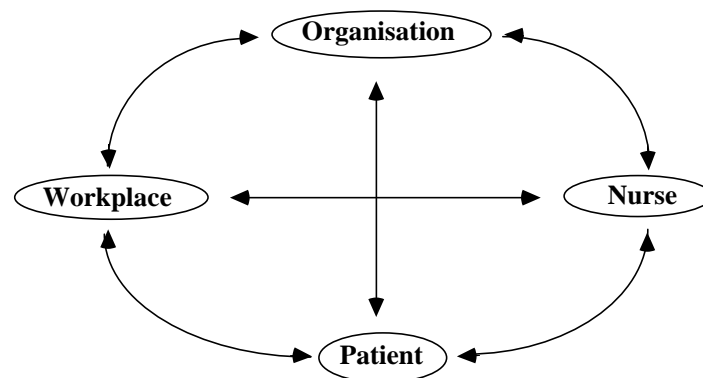
In Sweden, all working persons are compulsorily insured against occupational injuries. Employers are responsible for reporting such injuries on an injury form, which is sent to the social insurance office with a copy to the occupational health care unit.

The present thesis is based on data from the injury insurance forms, for which reason the ISA definition of an occupational accident has been used. An *accident* is therefore defined as a sudden event that can be referred to a certain time and place and lead to an *injury* that has been reported on an injury insurance form. Commuting accidents are not included. Only accidents leading to *over-exertion back injuries* were studied. In this thesis *accident* will be used when referring to the *event*, and *injury* when referring to the *reported physical harm* to any structures of the back due to the accident.

In study III a similar approach as that described in the OARU model was used. *Initial phase* refers to the deviations from the planned or normal process (see Table 1), *e.g.* shortage of staff or lack of transfer devices. The *concluding phase* refers to loss of control, *e.g.* a patient is falling and a nurse makes a sudden intervention to prevent this.

The *injury phase* is when energies meet the human body and cause physical harm, in the present study on some of the tissues in the back. *Patient transfer* refers to all kinds of transfer where the nurse physically supports the patient to some extent.

The study was based on the assumption that several factors and events interact in the accident process leading to a back injury. In the conceptual framework below (Figure 5) these factors and events are illustrated under four headings: *organisation*, *workplace*, *nurse* and *patient*. *Organisation* refers to factors that are



**Figure 5.** Conceptual framework for factors interacting in an accident process

directly affected by organisational procedures, *e.g.* kind of task performed, lack of information to the nurse, the co-worker, or shortage of staff. *Work place* includes the physical environment and its potential deficiencies, such as lack of transfer devices or lack of space, which compel the nurse to work in an awkward position. The *nurse* category, includes *e.g.* that the task was performed in a non-optimal way, despite the opportunity to perform the task in a safer way. *Patient* factors may, for example include that the patient suddenly lost his/her balance, or resisted, or was heavy.

**Table 1.** The factors assessed for whether they contributed or did not contribute to the accident, and seven factors describing the types of patient transfer included in the cluster analyses in Study III.

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<b><i>Organisation</i></b>	
1.	there was a lack of staff
2.	there was a lack of information to the nurse in transfer technique or how to use the transfer devices
3.	there was a lack of information concerning the patient's current condition that day
4.	there was a requirement for rehabilitation by the patient's physician
5.	the nurse felt rushed/stressed
6.	the nurse transferred the patient alone
7.	the co-worker lacked training in transfer technique or let go of the patient
<b><i>Workplace</i></b>	
8.	there was a risk in the environment
9.	there was no proper transfer device or it was out of order
10.	the nurse was compelled to work in an awkward position when performing the task due to some external factor, <i>e.g.</i> lack of space
<b><i>Nurse</i></b>	
11.	the nurse chose to perform the task in an awkward position
12.	there was a misunderstanding or lack of communication between nurse and patient
13.	the nurse was compelled to make a sudden movement, <i>e.g.</i> to save the patient from falling
<b><i>Patient</i></b>	
14.	patient weighed 80 kg or more
15.	the patient suddenly lost his/her balance or resisted during the transfer
<b><i>Type of patient transfer</i></b>	
16.	in bed
17.	to / from bed
18.	to / from toilet
19.	walking
20.	from floor
21.	to / from trolley / X-ray
22.	other transfer

---

The studies included in this thesis were reviewed and approved by the regional Ethics Committee of Human Research at Karolinska Institutet, Stockholm, Sweden.

## Study I

The study base in study I was composed of all female assistant nurses (199,089 women) working in Sweden at any time during the period January 1, 1985 to December 31, 1986. The cases were all assistant nurses who reported an over-exertion occupational injury due to an accident involving the back (excluding the neck) and who were absent from work for at least one day (Table 2). The following variables, obtained from the injury insurance form, were examined: age, years in present occupation, length of sick leave caused by the injury (days), place, main event and time of day.

**Table 2.** Total number of reported over-exertion back injuries due to accidents among assistant nurses in Sweden 1985-1986, in different age categories and showing their mean number of years in their present occupation.

Age (years)	18-24	25-34	35-44	45-54	55-64
Accidents 1985-86	1,047	731	844	593	337
Years in present occupation (mean)	1.8	5.7	7.3	16.8	12.5

## Study II

The aim of study II was to develop new instruments for systematic investigation of the accident process leading to over-exertion back injuries, including a sensitive screening tool for the physical environment to identify potential hazards. For this purpose interdisciplinary co-operation was considered important for ensuring that medical, ergonomic, psychological and work organisational views were taken into account. A task force of 24 persons was formed, including researchers from different fields and personnel from the Stockholm County Occupational Health Care Unit, to co-operate in this study and to develop the new instruments.

### *Development of the three instruments*

In order to establish a good basis on which to build preventive strategies, it was considered important to collect the opinions from the injured person as well as from the supervisor about the circumstances around the accident process, and to analyse the ergonomic environment objectively. Therefore three instruments were developed that could be used for discussion of preventive strategies: one structured interview protocol for the injured nurse, one for the head nurse and one ergonomic checklist.

### *Development of interview protocols*

The task force studied available questionnaires and publications concerning interview protocols and models for investigating accident processes or hazards (Backström et al., 1990; Carter et al., 1988; Döös et al., 1990; Kemmlert et al., 1987; Keyserling et al., 1991; Menckel et al., 1985; Troup, 1988; Wilson et al., 1990). Experience from previous back injury reports and interviews with injured persons were also discussed. The design of the instruments and the phrasing of the questions were discussed in detail and adjusted during regular meetings by the task force. The protocols were tested in two steps before the final version.

### *Development of the ergonomic checklist*

The ergonomic checklist covered the three spaces where most injuries due to accident occur: the patient's room, the corridor and the toilet (results from Study I). An additional part of the checklist concerned "other space": rooms for X-rays, treatment etc.

The checklist was developed as a rapid screening tool for hazard surveillance, intended for identifying factors in the physical environment that may impede nursing and/or transfer of patients. Lack of space, for example may force the nursing person to work in awkward postures that constitute a risk of injury (Keyserling et al., 1987; Troup, 1987).

The Swedish norms and directives for local planning and equipment for wards, as well as published checklists, were studied (Andren et al., 1979; Hallberg et al., 1982; Hansson et al., 1991; Kornberg, 1992; Spri, 1979). General instructions on how to use the checklist and a short key for each of its four parts were developed. The key consisted of guidelines for each item on the checklist.

The checklist was tested for inter-observer agreement by ten ergonomists who checked the presence or absence of hazards in a patient's room, a toilet and a corridor. The number of hazards was known only by the test leader.

## **Study III**

Study III was designed as a prospective, open cohort study. The source population consisted of all registered nurses, state enrolled nurses and nurse's aides (henceforth all referred to as nurses), totally 24,500 persons during the time of the study, employed in the Stockholm County hospitals. The study period was 12 months (March 1992-February 1993).

All nurses who reported an accident leading to back injury during the study period were contacted by an ergonomist from the occupational health care unit for an interview. So was the head nurse for the ward where the injured nurse worked. Totally 136 cases were identified, of which 130 agreed to participate. Nearly 60% of the 130 accidents were reported by state enrolled nurses, and about 20 % by registered general nurses and nurse's aides, respectively (Table 3). The number of participants and number of drop-outs in Study III-IV is presented in Table 4.



**Table 3.** Occupation, approximate proportion of the study population\*, mean age and experience of the specific task the nurse was performing when the accident occurred (n=130).

Occupation	Proportion of study population %	Proportion of injured %	Age (range) Years	Experience of specific task		
				< 1 year %	1-2 years %	≥ 3 years %
Registered general nurse	53	20	36 (21-54)	4	21	79
State enrolled nurse	30	59	32 (19-59)	8	24	68
Nurses' aide	17	21	33 (19-61)	4	4	92

\*Proportion of study population based on statistics for number of employed nurses in Stockholm County Council (Personal communication S-M Lindqvist, Federation of Swedish County Councils).

### *The interviews*

The standardised protocols developed in study II were used for systematic structured interviews with the injured nurses and the head nurse of the injured person's ward. At the time of the interview the ergonomist also assessed possible risks in the physical environment, following the ergonomic checklist, for the space where the accident had occurred. The interviewers were 12 ergonomists employed in the occupational health care unit and trained in interview technique. The interviews were carried out at the workplaces, in privacy.

### **Study IV-V**

Study IV and V had a prospective, case referent study design. The source population was the same as in Study III, but with a study period of 36 months (March 1992-December 1994).

The occupational health care unit sent a postal questionnaire to all those who had reported an accident leading to back injury during the study period.

Three referents for each case were randomly selected from the source population, taking sex and age (within a five-year interval) into account. The selection was made among the nursing personnel on the central hospital payroll that covers all personnel employed at any of the Stockholm County Hospitals. An inclusion criterion for the cases and the referents was that they should have worked at least one week during the three months preceding the injury (cases) and preceding the enrolment in the study (referents). The three referents per case were drawn once a month in order to ensure that the numbers of exposed cases and

**Table 4.** Number of subjects included in Study III-IV and number of drop-outs.

Study	Total number of subjects included	Cases	Referents	Drop-outs/excluded		Reasons for dropping out /being excluded
				Cases	Referents	
III	130	130		6		Did not want to participate
IV	854	240	614	20	157	Did not want to participate or did not answer
				1	27	Could not be traced at the address
V	673	220	453		73	Had a work-related back injury during the last 12 months which was not reported
				6	76	Never performed patient transfers
				14	37	Had missing data in any of the studied variables

unexposed referents would be in proportion to the length of exposed and unexposed person-time in the source population (Rothman et al., 1998).

Psychiatric wards were excluded since patient violence constitutes a more severe problem at these wards.

During the study period of Study IV and V, 292 cases and 877 referents were identified. Given the low number of men in the study, (n=110), the analyses were initially based only on the 854 women (240 cases and 614 referents, Table 5)

Due to the similarities in work tasks and the small number of nurses' aides, the state enrolled nurses and nurse's aides were combined into one group called "assistant nurses".

Seventy-two per cent of the registered general nurses had been working for 11 years or longer among the cases, compared with 66 per cent of the referents. A lower frequency had been working as long as this among the assistant nurses (31% among cases and 34% among referents).

#### *The questionnaires*

The questions concerned work organisation, physical exposure, psychosocial factors, background and life-style factors, musculoskeletal symptoms and prior accidents leading to back injuries. Most questions had fixed response alternatives, a few being followed by an open question to get additional information.

The exposure information referred to "the week before the back injury" for the cases and to "the last working week" for the referents, except for accidents which referred to the previous 12 months. This meant that a longer time passed between the assessed period and the filling in of the questionnaire for the cases than for the referents.

All exposures were dichotomised and the cut-off points between exposed (higher risk) and unexposed (lower risk) were decided from results in previous

studies, experience and knowledge of risk indicators and working conditions, and from the exposure distribution in the group studied (Table 6).

**Table 5.** Numbers of registered general nurses and assistant nurses, mean age, and years in the nursing profession among cases and referents in Study IV and Study V.

		Occupation	Mean age (Range) (years)	Years in nursing %		
				<1 year	1-10 years	≥11 years
STUDY IV	Cases	Registered general nurses N=60	38 (21-62)	0	28	72
		Assistant nurse N=180	32 (19-62)	2	67	31
	Referents	Registered general nurses N=261	37 (20-59)	0	34	66
		Assistant nurse N=353	32 (19-62)	6	60	34
STUDY V	Cases	Registered general nurses N=54	37 (21-62)	0	30	70
		Assistant nurse N=166	32 (19-62)	2	67	31
	Referents	Registered general nurses N=180	37 (20-59)	0	34	66
		Assistant nurse N=273	32 (19-61)	7	63	30

**Table 6.** The exposure factors included in the analysis in Study IV and Study V and their cut-off points between exposed (high risk) and unexposed (low risk). Included in the analysis in Study IV (IV) and in Study V (V). Exposure factors are categorised as attributed to either organisation or to nursing personnel, according to the conceptual framework (Figure 5).

Exposure factors	High risk	Low risk	Variables included in Study
	Exposed	Unexposed	
<b>Factors attributed to the organisation</b>			
Occupation	Assistant nurse	Registered general nurse	IV, V
Clinic, variable 1	Orthopaedic	Others	IV, V
Clinic, variable 2	Medical	Others	V
Working hours	≥35 hours/week	<35 hours/week	IV, V
Schedule	Rolling schedule	Fixed working hours	IV, V
Patient transfer	≥1 patient transfer/shift	<1 patient transfer/shift	IV, V
Perceived physical exertion (RPE 0-14)	RPE ≥8	RPE <8	IV
Training in patient transfer	No	Yes	IV, V
Practical training in use of transfer devices on own ward	No	Yes	IV, V
Use of transfer devices	<25 % of patient transfers	≥25 % of patient transfers	IV, V
Patient transfer alone when there should have been two	>1/10 patient transfers/shift	Never	V
<b>Factors attributed to the nurse</b>			
Back pain last week	Yes	No	IV
Prior back injury during last 12 months	Yes	No	IV, V
Job strain	Yes	No	IV
Body mass index (BMI)	BMI ≥25 kg/m <sup>2</sup>	BMI <25 kg/m <sup>2</sup>	IV, V
Current smoker	Yes	No	IV
Immigrant	Yes	No	IV, V
Physical training before age of 20	Only in school	Regular training	V
Physical training during last three months	≤once/week	≥once/week	IV, V
Self-rated fitness compared to others of the same age	≤Rather low	≥Medium	IV, V
Number of years in nursing	>10 years	≤10 years	V
Age	≥50 years	<50 years	V
Given birth to a child	Yes	No	V

## Data treatment and statistical analyses

### *Study I*

The incidence of occupational accidents leading to back injuries due to accident among nurses' aides was studied in relation to the total number of nurses' aides in Sweden. The total number was taken from the 1985 National Population and Housing Census (FoB -85). The incidence was determined for different age classes. The Annual Injury Incidence Rate (AIIR) per 1,000 workers was then calculated for each age group.

The relative risk (RR) with 95% confidence interval (95% CI) for over-exertion back injuries among nurses' aides was calculated with other employed women in Sweden as referents.

### *Study III*

Based on the information from the interviews with the injured nurse, a conditional probability model (Clayton et al., 1993) with the five categories patient work, patient transfer, planned transfer, use of transfer devices and type of patient transfer was calculated.

To identify the main types of accident processes and the pattern of contributing factors concerning patient work (125 cases), 22 factors regarded as likely to be involved in the accident processes were studied. These factors were based mainly on the free description given by the injured person, but also on answers to some of the specific questions in the protocol, the interview with the head nurse (staffing, weight of patient involved) and the ergonomic checklist (risks in the environment). Further, if relevant, the type of patient transfer was included.

By reviewing the free description, the two interview protocols and the checklist, three ergonomic experts independently assessed whether each of the factors had *contributed directly to the accident process* or not. They also judged whether the relevant type of patient transfer was identified (Table 1). The experts' assessments were compared, and in a few cases of disagreement discussion led to consensus.

To identify groups of accident processes that were relatively homogeneous regarding the dichotomous factors, cluster analyses were performed. The analyses were based on the Dice similarity measure for dichotomous data, which puts stronger weight on the joint presence of a factor than on the joint absence in a pair of cases. Clusters were formed using the average linkage-within-groups method, which minimises the average distance between all pairs in the cluster (Everitt, 1980). Different numbers of clusters (5-8) were tested. Pearson's Chi<sup>2</sup> test was calculated for all factors to obtain an indicator of how clearly a variable discriminated between clusters. All the analyses were performed with the SPSS program (Norusis, 1990). Two outliers representing unique accident processes were excluded from the analysis.

### *Study IV*

The relationships between exposure factors (Table 6) and back injury were estimated, controlling for age (<40 years ≥40 years), by calculating the adjusted

odds ratio (OR) for reporting over-exertion back injury, with a 95 per cent confidence interval (95% CI) The OR was interpreted as an estimate of the incidence rate ratio (RR) in the present population-based case referent study (Mietinen, 1976). All variables were entered into a logistic regression analysis using Maximum Likelihood estimates. The logistic regression models were tested for goodness of fit using the Hosmer and Lemeshow method (Hosmer et al., 1989). The logistic model was also tested for the male nurses (not reported in the original paper).

Additionally, the potential modifying effect for the risk of patient transfer, of training in patient transfer, practical training in using the transfer devices on their own ward and of frequent use of transfer devices, was investigated by calculations of the stratum specific OR.

All analyses were performed with the statistical computer program SAS (SAS Institute, 1997).

#### *Study V*

To identify the pattern of risk or protecting factors for accidents leading to back injury in the work situation among nurses who regularly performed patient transfer, cluster analyses were performed. These analyses included the variables that referred to the work situation and that had been found to be associated with the highest risk in Study IV: working hours, working on a rolling schedule, performing one or more patient transfers/shift and occupation. Also included were whether or not the nurse frequently performed patient transfers without using devices or performed patient transfers alone (Table 6).

Since the studied injuries almost always occur during patient transfers, persons who had claimed that they never transferred patients were excluded from the study. Totally 34 per cent of the total group were cases and 66 per cent were referents (Table 4).

The cluster analysis was based on the simple matching similarity measure, which gives the same weight on the joint present as on the joint absence of a factor for two cases. Clusters were formed using the average linkage-within-groups criterion (Everitt, 1980). When determining the number of clusters, one criterion was how well the clusters differentiated between cases and referents. The effects of the potential modifying factors (Table 6) were tested by cross-tabulating each factor with the case-referent grouping *within* each cluster for testing whether the potential modifying factor discriminated significantly between cases and referents in the same cluster.

# Results

## Study I

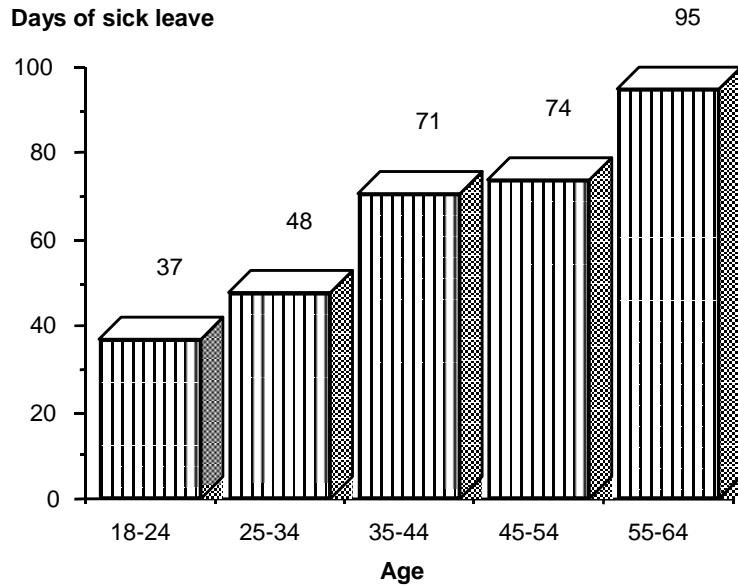
Accidents leading to over-exertion back injuries were reported by 8,954 women in Sweden during the two-year period. Of these women, 40% (3,552 cases) were assistant nurses.

The annual injury incidence (AIIR) per 1,000 assistant nurses was 8.92. Related to the number of employees in each age group, the youngest age group (18-24 years) had the highest incidence per year, with an AIIR of 12.2 (Table 7). Within this group, the age group 18-19 years had an AIIR of 14.5, and for the age group 20-24 years it was 11.4.

The relative risk of reported injury among assistant nurses compared with other Swedish employed women was 6.00 (95% CI 5.75-6.26). The age groups 18-24 years and 35-44 years had the highest relative risk (Table 7). The mean duration of sick leave was 59 days for the whole group (median 13 days). The length of sick leave increased with age (Figure 6).

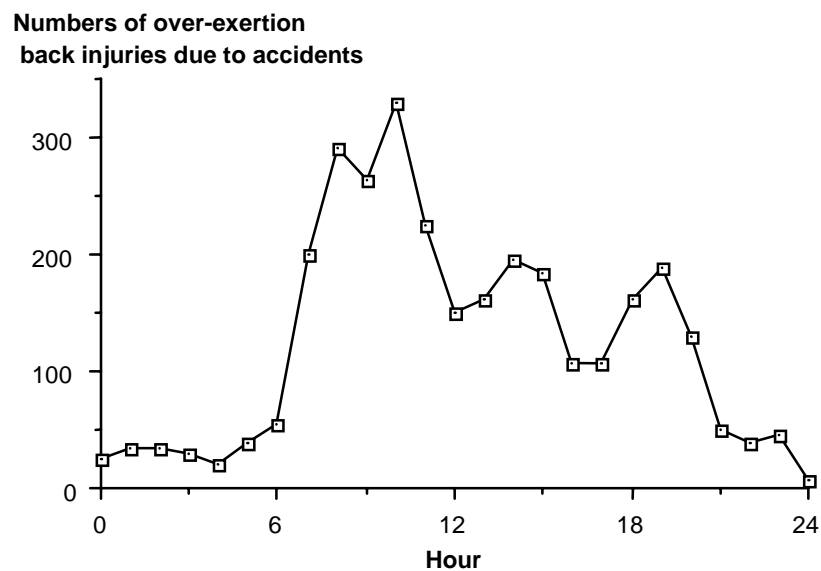
**Table 7.** Total number of reported over-exertion back injuries due to accidents among assistant nurses in Sweden during the period 1985-1986. Annual injury incidence rate (AIIR) per 1,000 assistant nurses and relative risk (RR) with 95% confidence intervals (95% CI).

Age	18-24	25-34	35-44	45-54	55-64
AIIR	12.2	6.9	9.3	8.3	7.7
RR (95% CI)	6.9 (6.3-7.5)	5.1 (4.5-5.6)	6.8 (6.2-7.4)	4.6 (4.1-5.1)	5.7 (5.0-6.4)



**Figure 6.** Mean number of days of sick leave following over-exertion back injuries due to accidents.

Most accidents occurred on wards and in corridors (84%). In 13% of the reported accidents, the accident occurred in the toilet room. The major risk situation was lifting, which was involved in 84% of the accidents. The distribution of the accidents varied during the twenty-four hours with a peak between 8-10 am. (Figure 7).



**Figure 7.** Distribution of the reported over-exertion back injuries due to accidents during 24 hours.



## Study II

### *Interview with the injured person*

The final version of the interview protocols contained 83 questions to be answered by the injured nurse and three for the investigator to answer after the interview. The protocols started with a few basic questions regarding occupation, time and place of the accident, followed by a free description of the accident process (Table 8). Detailed questions followed concerning the accident and the working conditions just before the accident. Depending on whether the accident occurred while handling/transferring a patient or material, the injured person answered questions directed towards the situation. Most questions had closed response alternatives, but there were also a few open questions.

### *Interview with the supervisor of the injured person*

The interview instrument contained 38 questions to the supervisor, and started with a free description to get the supervisor's own view of the accident process (Table 9). Detailed questions followed concerning the working conditions just before the accident event and concerning work organisation on the ward. Most questions had closed response alternatives, only a few questions were open.

**Table 8.** Arrangement of the interview protocol for the injured person. Numbers of questions (q) are given in brackets

---

1.	Basic questions (5 q)
2.	Time and place of the accident (3 q)
3.	Free description
4.	Causes leading to the accident (3 q)
5.	Preventive measures (4 q)
6.	The injured person's history of prior accidents leading to over-exertion back injury (3 q)
7.	Accident in connection with handling/transferring patients (17 q)
8.	Assistive devices/equipment for handling/transferring patients (8 q)
9.	Accident in connection with handling /transferring objects (9 q)
10.	Experience (7 q)
11.	Instructions in safe handling (6 q)
12.	Consequences of the accident (7 q)
13.	Potential contributing factors leading to the accident (11 q)
14.	The investigator's opinion about the main cause (3 q)

---

**Table 9.** Arrangement of the interview protocol for the supervisor of the injured person. Numbers of questions (q) are given in brackets.

- 
1. Free description of the accident process
  2. Causes leading to the accident (2 q)
  3. Organisation of work on the ward (4 q)
  4. Information to ward staff (6 q)
  5. Physical exercise for the staff (2 q)
  6. The day of the accident (7 q)
  7. Accidents which occurred during patient care (4.q)
  8. Prior accidents leading to over-exertion back injuries on the ward and suggestions for preventive measures (6 q)
- 

#### *Ergonomic checklist*

The checklist was designed as a rapid screening tool to discover potential risk factors in the physical environment for back accidents among nursing personnel. It contained general instructions for use, and three parts covering the patient's room, the toilet, and the corridor. There was also one part for "other space", to be used when investigating rooms for X-rays, treatment etc. For each part there was a key with guidelines. Most of the items in the key were based on the norms and directives in force for local planning and equipment for patients' rooms, toilets and corridors. When there were no norms and directives, the item was based on a subjective ergonomic assessment. For each item, the key gave a short description of the norm or directive, or an explanation of what is meant by, for example, "unsatisfactory" or "insufficient" in the checklist. The key also gave requirements concerning minimum dimensions, depending on the patients' different needs for assistance, and references to the relevant norm or directive were given in the key.

For all items in the checklist the observer noted whether a risk factor was present or not, thus minimising the risk of overlooking a hazard. If a hazard was observed, the observer further specified what constituted that hazard. The observer also judged whether the observed hazard had contributed to the reported accident and whether the risk factor should be eliminated immediately or in the long run.

#### *Inter-observer reliability*

Nine out of ten observers agreed as to the presence or absence of the hazards for 19 of the 26 items in the checklist.

### **Study III**

In 44% of the reported accidents leading to injury the nurse went on sick leave (median 14 days, range 1 day-8 months). Medical care was sought by half of the nurses (55%) and analgesic was taken by 64%. Altogether 39% of the nurses had

previously experienced a similar accident leading to over-exertion back injury at work. In this group, 52% had reported it on a work injury insurance form.

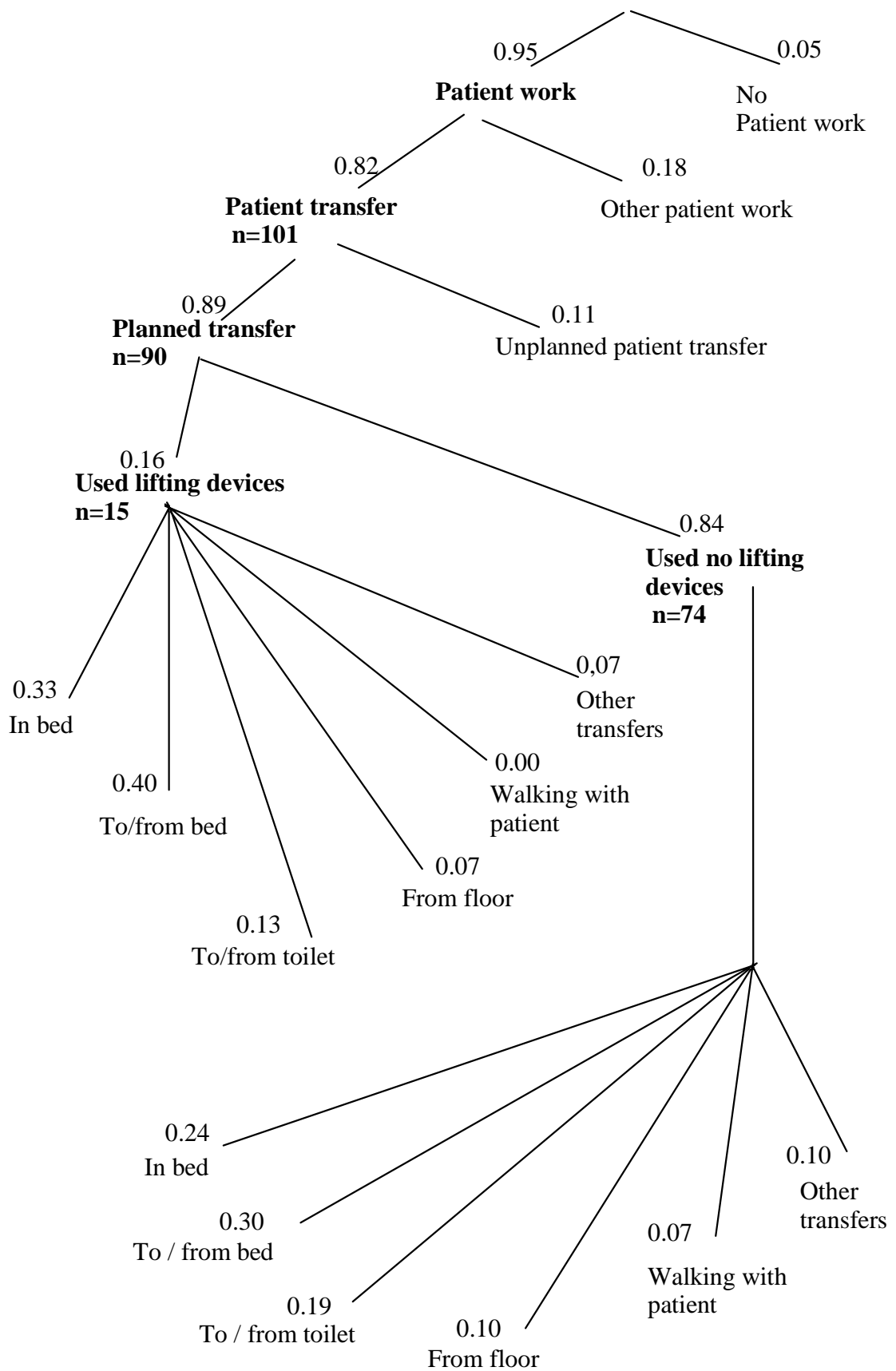
### *Organisation*

Nearly all accidents occurred while the nurse was working with a patient, most often during patient transfer (Figure 8). The most frequent form of patient transfer involved movements in the bed, or to or from bed. Other activities were, for example, washing or feeding the patient. In five cases the injury occurred while objects were being moved.

In half of the events (52%) two nurses co-operated and in 35% the nurse performed the task alone. Of the latter 52% said that they usually managed alone, whereas 18% said there was no one else available.

Most of the accidents occurred during a “planned” activity (Figure 8), meaning that it was possible for the nurse to consider how to perform the task and whether transfer devices should be used. In 11% of the accidents, the nurse made a sudden intervention, for example to prevent the patient from falling out of bed. As seen in figure 8 transfer devices were used in 16% of the patient transfers. The reasons most often given by the nurse for not using a transfer device were: she did not think it was necessary, there was not enough space, there was no suitable transfer device; the devices were inconveniently stored or there was an emergency. The devices used were most often a walking-belt or a draw-sheet.

The task performed in connection with the accident was in 46% of the cases one that they usually carried out one to several times a day, and in 10% of the cases they usually did it several times per hour. Sixty-five per cent of the nurses said they had enough time to plan how to perform the task.



**Figure 8:** Probability tree for the different tasks performed when the accident occurred (n=130)

### *Workplace*

The site of the accident was the patient's room in 59 % of the cases, a toilet in 12%, and a corridor in 11 %. The remaining sites were treatment rooms, X-ray rooms, showers, emergency entrances, etc. Most injuries occurred in surgical wards (23%), medical wards (17%) or wards for chronically ill patients (13%). The rest were distributed over remaining wards.

### *Nurse*

Eighty per cent of the nurses said that they had followed the given instructions when performing the task. The reasons given by the injured person for not following instructions were, for example, that it would have taken too long, that there was not enough space; that it was an emergency or that it was inconvenient.

### *Patient*

The patients weighed between 33 and 180 kg, with an average weight of 81 kg. Totally one third of the accidents occurred with wheelchair patients, when they were being transferred between the bed and the wheelchair (20%) or between the toilet and the wheelchair (13%).

### *Pattern of factors involved in the accident process*

The six clusters extracted by the cluster analysis represented well-defined types of accident processes. Table 10 presents the extent to which the 22 different factors were present in each cluster

In what follows the clusters will be referred to as cluster 3:1-3:6 as opposed to cluster 5:1-5:6, which are the labels used for the clusters identified in Study V.

*Cluster 3:1: Patient lost control during transfer to/from bed or toilet* (43 cases). The nurse had to make a sudden movement to prevent the patient from falling. In half of the cases, the nurse was compelled to work in awkward positions due to a risk in the environment, most often a lack of space. Misunderstandings between nurse and patient contributed in about half of the accidents.

*Cluster 3:2: The nurse was compelled to work in an awkward position* either due to lack of transfer devices or a risk in the environment, most often lack of space (39 cases). The nurses often felt stressed. The patients who were heavy, lost control or resisted in half of the accidents. The most frequent patient transfers were in bed.

*Cluster 3:3: The nurse walked alone with the patient and the patient lost control*, obliging the nurses to make a sudden movement to prevent the patient from falling (13 cases). In more than one-third of the accidents, there was a requirement for rehabilitation by the patient's physician.

**Table 10.** Results of the cluster analysis of factors and events assessed as directly contributing to the accident process. The proportion of cases in which the factor was present is given for each cluster. The factors judged to characterise the cluster are printed in bold. The p-value from the Chi<sup>2</sup> test is an indicator of how well the clusters are differentiated by the factor.

	Cluster 1 n=43	Cluster 2 n=39	Cluster 3 n=13	Cluster 4 n=14	Cluster 5 n=4	Cluster 6 n=10	
Factors and events	Prop.	Prop.	Prop.	Prop.	Prop.	Prop.	p value
<b>Organization</b>							
Lack of							
-staff	.28	.21	.00	.07	.00	.10	.14
-info. on transfer techniques	.28	.31	.15	.29	.25	.00	.44
-info. re. patient's condition	.33	.00	.08	.00	.00	.00	.00
Rehabilitation demands	.12	.00	<b>.39</b>	.00	.00	.00	.00
Stressed	.14	<b>.54</b>	.08	<b>.50</b>	.00	<b>.90</b>	.00
Transferred alone	.30	.28	<b>.69</b>	<b>1.00</b>	.00	.20	.00
Co-worker	.12	.08	.00	.00	<b>1.00</b>	.00	.00
<b>Workplace</b>							
Risk in environment	<b>.47</b>	<b>.60</b>	.23	.21	.00	.00	.00
Lack of transfer devices	.14	<b>.62</b>	.23	.14	.00	.30	.00
Compelled to work in awkward position	<b>.51</b>	<b>.85</b>	.15	<b>.43</b>	.00	.00	.00
<b>Nurse</b>							
Awkward position	.16	.03	.08	<b>.57</b>	<b>.50</b>	<b>1.00</b>	.00
Lack of communication	<b>.51</b>	.26	.31	.07	.00	.00	.00
Compelled to make a sudden movement	<b>.74</b>	.36	<b>.85</b>	.07	<b>.50</b>	.10	.00
<b>Patient</b>							
Weight >80 kg	.28	<b>.56</b>	.15	<b>.57</b>	.00	.20	.01
Patient lost control	<b>.88</b>	.49	<b>.92</b>	.07	.25	.30	.00
<b>Patient transfer</b>							
In bed	.02	.31	.16	.43	<b>1.00</b>	.00	.00
To / from bed	<b>.54</b>	.15	.00	.36	.00	.20	.00
To / from toilet	.30	.08	.00	.07	.00	.00	.01
From floor	.00	.10	.08	.00	.00	.30	.01
Walking with patient	.00	.00	<b>.69</b>	.00	.00	.00	.00
To / from trolley	.05	.08	.08	.14	.00	.30	.20
Other transfer	.02	.21	.00	.00	.00	.10	.02

*Cluster 3:4;* The nurse transferred a patient alone in bed or to/from the bed (14 cases). The patient was heavy in nearly 60% of the cases. All nurses worked in an awkward position, and nearly half of them were compelled to do so. In half of the cases the nurse felt stressed.

*Cluster 3:5:*The co-worker lost grip of the patient during transfer in bed (4 cases).

Cluster 3:6: *The nurse worked in an awkward position, most often in combination with stress (10 cases)*. The most frequent patient transfers were from the floor or to/from the trolley or the bed.

#### **Study IV**

Quite similar estimates was observed for the RR in the age-adjusted and in the logistic regression analyses (Table 11 and Table 12).

##### *Risk indicators in the workplace*

Assistant nurses ran a higher risk of back injury than registered general nurses (Table 11 and Table 12). Work at orthopaedic wards entailed a higher risk of back injuries than work at all other clinics. Increased relative risk was also found for nurses who worked full-time, and for those who worked on a rolling schedule.

There was an increased relative risk for back injury among nurses who transferred patients once or more per shift (Table 11 and Table 12). The median number of patient transfers among exposed nurses was within the response alternative 3-10 transfers per shift for both the registered general nurses and the assistant nurses. Of the assistant nurses, 34% made  $\geq 11$  transfers/shift compared to 14% among the registered general nurses. Of nurses who worked part-time, 24% made  $> 11$  transfers/shift compared to 19 % among nurses who worked full-time.

The median value for using transfer devices was 10% of the patient transfers among registered general nurses, as compared to assistant nurses who used transfer devices in 25% of the transfers.

**Table 11.** Adjusted relative risks (RR) with 95% confidence intervals (95% CI) for reporting back injury. The relative frequency (%) of exposed cases and exposed referents are also presented. Adjusted for potential confounding from age (<40, ≥40 years). The unexposed group consists of all other subjects not exposed according to the exposure definitions (see Table 6)

Exposure factors	Exposed cases		Exposed referents		RR (95%CI)
	n=240	%	n=614	%	
Assistant nurse/ Registered general nurse	75		57		2.2 (1.6-3.1)
Orthopaedic/other clinic	15		3		6.8 (3.9-11.6)
Working full-time/ part-time	78		56		3.0 (2.1-4.2)
Rolling schedule / Fixed working hours	83		67		2.4 (1.7-3.5)
Patient transfer ≥1/ shift	88		69		3.3 (2.2-5.1)
Perceived physical exertion (RPE>8)	63		47		2.0 (1.4-2.7)
Back pain during last week	45		51		0.8 (0.6-1.1)
Prior back injury during last 12 months	20		12		1.8 (1.2-2.7)
Job strain	21		19		1.2 (0.8-1.7)
Body mass index (BMI ≥25 kg/m <sup>2</sup> )	31		25		1.3 (1.0-1.9)
Current smoker	37		30		1.4 (1.0-2.0)
Immigrant	22		15		1.7 (1.1-2.4)
Physical training ≤once/week	57		55		1.1 (0.8-1.5)
Low self-rated fitness	28		30		0.9 (0.7-1.3)



**Table 12.** Relative risks (RR) among female nurses and male nurses in logistic regression models, with 95% confidence intervals (95% CI) for reporting back injury (cases n=240 women and 39 men, referents n=614 women and 79 men). Potential confounding from age (<40, ≥40 years) was controlled for. Hosmer and Lemeshow test p=0.78 for female nurses and p=0.73 for male nurses. The unexposed group consists of all other subjects not exposed according to the exposure definitions (see Table 6).

Exposure factors	RR (95% CI)	
	Female nurses	Male Nurses
Assistant nurse / Registered general nurse	1.5 (1.0-2.3)	3.6 (1.0-15.3)
Orthopaedic clinic / other clinic	5.2 (2.7-10.2)	25.6 (2.8-600.4)
Working full-time / part time	2.4 (1.6-3.6)	7.3 (1.5-52.8)
Rolling schedule / fixed working hours	1.3 (0.8-2.1)	0.4 (0.1-1.6)
Patient transfer ≥1/shift	2.7 (1.6-4.5)	2.0 (1.4-11.1)
Perceived physical exertion (RPE>8)	1.2 (0.8-1.8)	1.9 (0.6-6.7)
Back pain during last week	0.7 (0.5-1.0)	2.3 (0.6-9.0)
Prior back injury during last 12 months	1.8 (1.2-2.9)	1.4 (0.3-5.7)
Job strain	0.9 (0.6-1.3)	1.6 (0.3-7.5)
Body mass index (BMI≥25)	1.4 (0.9-2.0)	1.4 (0.4-4.6)
Current smoker	1.1 (0.8-1.6)	1.8 (0.5-6.3)
Immigrant	1.6 (1.0-2.4)	3.0 (0.9-11.4)
Physical training ≤once/week	1.0 (0.7-1.5)	1.5 (0.1-1.7)
Low self-rated fitness	0.8 (0.6-1.2)	1.9 (0.4-8.7)

*Risk indicators attributed to the nurse*

A slightly higher relative risk of patient transfer was observed among nurses older than 40 years (RR=3.7 CI=1.8-7.6) compared to the younger nurses (RR=3.1 CI=1.8-5.3), while the relative risk was markedly higher among nurses older than 50 years (RR=6.3 CI=1.8-22.9) compared to the younger nurses (RR=2.9 CI=1.9-4.7).

The mean rating of physical exertion during work was 8.0 (Sd 2.4). The elevated relative risk found among nurses who reported high physical exertion during work (Table 11) decreased when considering other exposures (Table 12).

A prior back injury during the last 12 months had occurred to 47 cases (20%) and to 73 referents (12%) and thus increased the relative risk of a new injury. In 95% of the cases and 94% of the referents, the prior injuries had not been reported on an injury insurance form. No relation was found between back pain during the previous week and reported back injury (Table 11).

Job strain during work was not related to reported back injury.

Twenty-three per cent of the cases and 16% of the referents were immigrants. Nearly half of the immigrant cases, and one-fourth of the referents, were from a country outside Northern Europe. Immigrants had an increased relative risk (Table 11), with the highest risk among those below 40 years (RR=2.1 CI 1.3-3.3).

Nurses performing no regular physical training or having low self-rated fitness did not show an increased relative risk of over-exertion back injury (Table 11 and Table 12).

#### *Male nurses (Previously unpublished data)*

Most of the factors that constituted a risk for female nurses seemed to be harmful also among the male nurses, except for working on a rolling schedule (Table 12). Among men back pain during the last week, job strain, smoking, no regular physical training and low self-rated fitness also indicated harmful effects. However, due to the low number of men, 110 nurses, the confidence intervals were too wide to draw any conclusions regarding potential differences between men and women.

#### *Training and use of transfer devices*

Practical training in how to use the transfer devices on their own ward, and also the use of transfer devices, modified the risk of patient transfer (Table 13). No difference in RR of patient transfer was however observed between nurses with more than one day of training in patient transfer, and those with less than one day.

**Table 13.** Relative risk (RR) and 95% confidence intervals (95% CI) of patient transfer ( $\geq 1$  times/work shift compared with  $< 1$  times/work shift) for reported back injury among nurses who differed in patient transfer training, practical ward training on transfer devices and use of transfer devices, respectively.

	RR (95% CI)
Training in patient transfer	
$\geq 1$ day	3.7 (1.9-7.1)
$< 1$ day	3.0 (1.7-5.3)
Practical ward training on transfer devices	
Yes	1.6 (0.9-2.8)
No	6.0 (3.0-12.0)
Use of transfer devices	
$\geq 1/4$ of all patient transfers	1.5 (0.6-3.4)
$< 1/4$ of all patient transfers	3.9 (2.3-6.6)

## Study V

### *Patterns of work-related factors and their modifiers*

A six-cluster solution including occupation, discriminated best between cases and referents. The proportion of cases varied widely between the clusters (between 9 and 47 per cent). In two of the clusters, cases were over-represented (cluster 5:1 and 5:2, Table 14), and in three clusters (cluster 5:3, 5:4 and 5:6) they were under-represented. Table 14 presents the extent to which the six included factors related to the work conditions were present in each cluster.

*Cluster 5:1.* This cluster was the largest with 247 nurses, 43% of whom were cases, which means that there was an increased risk of reporting an over-exertion back injury in this cluster, OR=2.1 (95% CI=1.5-2.9). Nearly all cluster members worked full-time and most of them worked on a rolling schedule. Almost all of them transferred patients regularly during their working shift, and there were very few who did not use transfer devices frequently during these transfers.

The analyses of the differences between clusters in the modifying variables showed that cluster 1 differed from most of the other clusters in many respects (Table 15) For example, more nurses in this cluster than in the others had had training in lifting techniques and practical training with devices.

*Cluster 5:2.* This cluster was the second largest (127 nurses) and had the highest percentage of injuries (47%, OR=2.2 (95% CI=1.5-3.2) The main differences between this cluster and cluster 5:1 were that nurses in cluster 5:2 seldom used

transfer devices, and almost all of them frequently performed patient transfers alone, even when they judged that there should have been two nurses (Table 14).

The analyses of the differences between clusters in the modifying variables (Table 15) showed that in this group the highest percentage worked in orthopaedic clinics, had had a prior back injury, had given birth to a child and did not report regular physical training

*Cluster 5:3.* This cluster included 87 nurses, 20% of whom had reported an injury, which means there was a decreased risk for reporting an over-exertion back injury in this cluster OR=0.5 (95% CI=0.3-0.8). All cluster members worked part-time, nearly all transferred patients regularly but seldom used transfer devices, and nearly all were assistant nurses. (Table 14).

The analyses of the differences between clusters in the modifying variables showed that nurses in this cluster had less training in patient transfer and less practical training with transfer devices compared to the other clusters. (Table 15).

*Cluster 5:4.* This cluster was the smallest, including 62 nurses and the second lowest percentage of injuries (16%, OR=0.4 (95% CI=0.2-0.7). The cluster members worked part-time, nearly all of them transferred patients regularly, but few of them used transfer devices frequently. All of them were registered general nurses (Table 14).

The analyses of the differences between clusters in the modifying variables showed that none of the nurses in this cluster had had a prior back injury, and that it contained the largest percentage of nurses who had worked more than 10 years (Table 15).

*Cluster 5:5.* This cluster included 76 nurses, 26% whom had reported an injury OR=0.7 (95% CI=0.4-1.2). All cluster members worked part-time, nearly all of them transferred patients regularly, all of them often used transfer devices regularly during patient transfer and nearly all in this cluster were assistant nurses. (Table 14).

The analyses of the differences between clusters in the modifying variables showed that this cluster did not differ from the other clusters in any of these variables (Table 15).

*Cluster 5:6.* This cluster included 74 persons. It had the lowest injury rate (9%), and a decreased risk for reporting an injury OR=0.2 (95% CI=0.1-0.4). No one transferred patients regularly during their working shift, and therefore they did not use transfer devices or frequently perform patient transfers alone (Table 14).

The analyses of the differences between clusters in the modifying variables showed that this cluster contained the lowest percentage of nurses from medical clinics, and nurses in this cluster reported more often than in other clusters that they performed regular physical training (Table 15).

**Table 14.** The proportion exposed to the potential risk indicators for back injury in the six clusters. Indicators with a proportion of  $\geq 0.90$  or  $\leq 0.10$  in each cluster are in boldface. 1.00 = all members in the cluster were exposed to the risk indicator and 0.0 = none had the risk indicator in the work condition. The Odds Ratio with 95% confidence interval (95% CI) for reporting back injury.

	Cluster 5:1 n=247	Cluster 5:2 n=127	Cluster 5:3 n=87	Cluster 5:4 n=62	Cluster 5:5 n=76	Cluster 5:6 n=74
Percentage of injuries in cluster	43%	47%	20%	16%	26%	9%
Number of injuries / expected number	106 / 80.7	60 / 41.5	17 / 28.5	10 / 20.3	20 / 24.8	7 / 24.2
Odds Ratio	2.1	2.2	0.5	0.4	0.7	0.2
95% CI	(1.5-2.9)	(1.5-3.2)	(0.3-0.8)	(0.3-0.7)	(0.4-1.2)	(0.1-0.4)
Factors	Prop	Prop	Prop	Prop	Prop	Prop
Working full-time	<b>0.96</b>	<b>0.99</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	0.58
Working on a schedule	0.87	0.88	0.44	0.44	0.70	0.62
$\geq 1$ patient transfer / shift	<b>0.94</b>	0.87	<b>0.90</b>	<b>0.98</b>	<b>0.99</b>	<b>0.00</b>
Use of transfer devices in <25% of patient transfers	0.11	<b>1.00</b>	<b>1.00</b>	<b>0.97</b>	<b>0.00</b>	<b>0.95</b>
>1/10 patient transfers alone	0.55	<b>0.98</b>	0.80	0.48	0.71	<b>0.00</b>
Working as an assistant nurse	0.70	0.72	<b>0.98</b>	<b>0.00</b>	<b>0.91</b>	0.28

**Table 15.** Proportions of potential risk indicators and modifying factors in each cluster among nurses who had reported an over-exertion back injury.

Modifying factors	Cluster 5:1	Cluster 5:2	Cluster 5:3	Cluster 5:4	Cluster 5:5	Cluster 5:6	P-value
	n=247	n=127	n=87	n=62	n=76	n=74	
	% of the cluster	% of the cluster	% of the cluster	% of the cluster	% of the cluster	% of the cluster	
Medical clinic	54	49	55	47	68	38	0.01
Orthopaedic clinic	9	12	1	2	5	3	0.01
<1day of training in patient transfer	43	57	69	57	54	66	0.00
Practical training in use of transfer devices	33	58	69	63	40	68	0.00
Prior back injury during last 12 months	8	13	1	0	7	3	0.00
>10 years in nursing	22	24	35	40	25	30	0.03
Present physical training <once/week	75	76	62	55	54	52	0.01
Given birth to a child	67	65	43	21	41	37	0.00

*Effects of potential modifying factors within each cluster*

A number of the tested modifiers (working in a medical clinic, training in patient transfers, practical training in the use of transfer devices on their own ward, back pain during the last week, age  $\geq 50$  years, BMI  $\geq 25$ , self-rated fitness or immigrant status) showed no association with risk of injury within any cluster.

In the two clusters with an over-representation of cases (clusters 5:1 and 5:2) the risk of injury was further increased among those who had had a previous back injury (p=0.00). Other factors associated with an increased risk within a cluster were working in an orthopaedic clinic (5:1 and 5:3, p=0.00), no current physical training (5:3, p=0.04), and having had physical training only in school before the age of 20 (5:2, p=0.01) and having worked more than 10 years in nursing (5:4, p=0.04). Having given birth to a child was associated with a decreased risk of injury in cluster 5:3 and 5:5 (p=0.02 and 0.01, respectively). Previous back injury discriminated both *between* the high- and low-risk clusters, and between cases and referents *within* the high-risk clusters, and, thus, is especially likely to be a critical condition for the occurrence of over-exertion back injury.

# Discussion

## **The instruments for investigating the accident process**

The interview protocols appear suitable for investigating over-exertion back accidents. The checklist showed good inter-observer reliability for most items. The checklist can also be used as a screening tool to identify hazards for back accidents in a regular preventive ergonomic workplace walk-through, and thereby prevent accidents (Kornberg, 1992). This basic concept could be transferred to accident investigations and preventive work in other fields.

It is important to use the employee's experience to prevent accidents. The present instruments focused on systematic recording of this experience. The instruments have also formed a good basis for discussions and co-operation among employees, supervisors and investigators leading to preventive strategies (Menckel et al., 1997).

## **Risk factors related to the work organisation**

### *Occupational group*

The observed high relative risk among assistant nurses compared to registered general nurses is in agreement with other studies (Heap, 1987; Venning, 1987). This may partly be explained by differences in work tasks. Assistant nurses most often carry out more patient transfers and a greater share of other practical nursing tasks, *e.g.* feeding and dressing. Assistant nurses spend on average 71% of their working time on patient-handling tasks, compared with 41% for registered general nurses (Josephson et al., 1999). Bending and rotating motions are also more common among assistant nurses (Videman et al., 1984).

The Swedish health care organisation is changing, so in the future registered general nurses will do more of the practical nursing and thereby be at greater risk for back accidents.

### *Type of clinic*

Nurses working at orthopaedic clinics showed the highest relative risk of back injury (Study IV). This might be because patients at orthopaedic wards have often recently had surgery and/or have plaster or some other contrivance that impedes transfer both in bed and to/from bed. These patients are also trained to walk early when they are still weak and insecure.

### *Working hours*

Both working full-time and working on a rolling schedule involved a high relative risk (Study IV). Working full-time in physically heavy work may cause fatigue, and hence impaired neuromuscular control and awkward working movements and postures, which may increase the risk of back injury (Jørgensen, 1985). Fewer

health problems have been observed among nurses working less than 20 hrs/week than those working longer hours (Walters et al., 1996). Nurses who worked part-time did not perform fewer patient transfers per working shift than nurses who worked full-time. They may, however, probably perform a lower number of patient transfers calculated per week or month due to fewer working shifts.

#### *Working schedule*

Shift work may lead to sleep disturbances and fatigue, impaired work performance and lower safety awareness (Tan, 1991). There was a peak of reported over-exertion back injuries in the mornings, which is also the time of the day with most frequent patient handling (Study I). It has also been suggested that the increased risk of injury early in the morning is due to fully hydrated discs, higher bending stiffness and documented stresses on the structures associated with bending at this time of the day (McGill, 1997). The combination of highly intensive patient handling in the mornings, when the tissues are more vulnerable, and the short time for recovery between heavy patient handling tasks might increase the risk of injury.

#### *Patient transfers*

Most accidents in Study I and Study III -V involved a patient transfer, which is consistent with other studies (Estryn-Behar et al., 1990; Hignett, 1996; Jensen, 1990; Owen & Garg, 1991). Performing more than one patient transfer per working shift was one of the most pronounced risk indicators observed in Study IV. Surprisingly, most of the accidents occurred during ordinary planned patient transfers, when the nurse had time to prepare herself and the patient, and not in emergency situations (Study III).

One-third of the patient transfers in Study III were transfers between bed or toilet and wheelchair, which has been found to be one of the most stressful tasks in nursing (Owen & Garg, 1991). A frequent patient transfer was in the bed, which also create a high load on the back (Gagnon et al., 1987; Smedley et al., 1995).

Two or more nurses assisted the patient in two-thirds of the accidents. This shows that being two or more nurses sharing the burden does not necessarily prevent back accidents, which agrees with the findings of S:t Vincent *et al.* (S:t Vincent et al., 1995).

#### *Training in patient transfer*

A lack of information in transfer techniques was judged to be a contributing factor in all clusters except one (Study III). The interviews indicated that there was a need for training patient transfers, including emergency situations, such as when a patient has fallen on the floor.

The RR of patient transfer for back injuries was not lower among nurses who had had training in transfer technique compared with nurses who had not (Study IV), which is in accordance with other studies (Hignett, 1996; Hsiang et al., 1997; Stubbs et al., 1983). One reason may be that only the length of the training was considered; the effect of training may depend more on *e.g.* what techniques are



trained, how the training is performed and the extent to which the nurses use the technique. The relative risk of patient transfer was even slightly higher among nurses who had been trained in transfer techniques. One explanation might be that nurses who are trained are exposed to more risk factors. They may, for example, work on wards with more disabled patients.

### *Transfer devices*

Transfer devices were seldom used, which has also been found in other studies (Garg et al., 1992; Prezant et al., 1987).

The explanation of why transfer devices are so seldom used in hospitals is complex. In many cases one reason was lack of transfer devices (Study III). Additionally, lack of experience in using the devices, and difficulty in understanding how to use them, may also be part of the explanation (Bell, 1984; Owen, 1988). Nurses may also find it too impersonal to transfer patients in a hoist. Sometimes the patients prefer to be transferred manually. Compared to working in industry, the nurses cannot always choose the most labour-saving way, since they want to and have to consider the patient's comfort, pain, wishes, need for rehabilitation etc.

Patient transfers constituted less of a risk among nurses who had received practical training in using the transfer devices on their own ward, and for those who frequently used transfer devices (Study IV.) This shows the importance of having good transfer devices available on all wards, ensuring that they are easy to reach and easy to use, and having sufficient space for their use. Furthermore it is important to train nurses in how to handle the transfer devices on their own ward, in order to make the use of devices a natural part of the job. Based on Haddon's principle, manual lifts should be avoided by always using a hoist or a ceiling lift whenever the patient needs to be *lifted*, thereby eliminating one of the necessary conditions for an accident to occur.

### **Risk factors related to the workplace**

The two largest clusters in Study III (3:1 and 3:2) mainly involved transfers to/from bed or toilet and transfers in the bed. Risks in the environment, most often due to lack of space, but also lack of transfer devices, contributed to a high degree to the accident process in these clusters. This compelled the nurse to work in an awkward position and made it impossible to use a hoist. Nurses are, thus, often *forced* to perform their tasks in a risky way even when the patients are heavy and not co-operative. In spaces where there is too little room for a hoist, a ceiling-mounted lift should be installed. This requires a minimum of space and suits most patients.

## **Risk factors related to the nurses**

### *Age*

Nurses in all age groups had a high RR of over-exertion back accident compared to other Swedish women. The youngest age group had the highest AIIR (Study I). It might be that the younger nurses perform more patient transfers. The high AIIR might also be due to the lower bone mineral content and thus greater vulnerability among persons who are 18-19 years old, as among persons older than 50 years, compared to middle-aged persons (Hansson & Roos, 1986). One explanation for the obtained increased risk of patient transfer for nurses older than 50 years of age in Study IV, might be micro-fractures due to repeated lifts, but which may be marked by a culminating event (Dempsey et al., 1997; Hansson, 1989; Hansson et al., 1988; McGill, 1997). It might also be a result of the decreased strength of the tissues in the back due to age, or the combination of these two. In Study I it was shown that the number of days on sick leave increased with increasing age. An explanation for this might be that the injuries were more serious, or that it takes longer for the tissues to heal in older people compared to younger people.

### *Experience*

Nurses who reported an accident generally had long experience in their profession and also of the specific task they were performing when the accident occurred (Study III). These results contradict reports from industry, where persons with short experience usually have more accidents (Laflamme, 1992; Saari & Lahtela, 1981). However, in the present studies, only a small number of nurses had short experience.

### *Prior injury*

One of the highest risk factors found in this thesis was a prior injury, which has been shown earlier (Bigos et al., 1991; Dempsey et al., 1997; Wohl et al., 1995).

There could be different explanations of these repeated injuries. One might be that the prior injury makes the person more vulnerable to a new injury. A second explanation might be that the work load on some wards is so high that it leads to repeated injuries, *i.e.* the prior injury is merely an indicator of a high-risk work situation. A third explanation might be that some persons are more vulnerable by nature.

The accidents reported in this study might be cumulative injuries by nature, especially as quite a few of the nurses had also reported a similar accident earlier. But whether the injuries are a result of cumulative stress or of one specific peak load, the most important task is to identify the risk situations and the contributing factors where the over-exertion of tissues occurs, so that the accidents leading to the injuries can be prevented.

### *Male nurses*

Due to the low number of men, the male nurses were excluded from the main analyses. However, the factors identified as risks for women seem to be harmful

also for men. The precision is, however, too low to permit any conclusions regarding potential differences between gender.

### **Factors involved in the accident process**

The cluster analyses in Study III were based on the assumption that the factors were judged, by three ergonomic experts, to have directly contributed to the accident, not simply to have been present. Provided that these judgements were valid, the clusters form a good basis for a choice of effective preventive measures. Hence the most effective measure would be to improve the physical conditions, *e.g.*, shortcomings in the environment and lack of transfer devices, that compel the nurse to work in a way which is unsafe for the nurse and for the patient. For a large group, however, organisational factors contributed to the accident process, which shows the need for better staff planning, information to and training of nurses, better planning of rehabilitation, etc.

Also, the nurse sometimes felt that she had to perform the task in an awkward position due to stress. It is important that there is enough staff so that the nurses do not have to feel that they always have to choose the fastest way to perform the task, but have time to plan the patient transfer, and to consider what kind of devices could be used, whether a co-worker is needed etc.

To prevent back injuries it is important to give nurses instruction and training in how to transfer each patient in the most labour-saving way, and regarding which devices should be used to achieve this. The nurses must also be trained to prepare themselves and the patient before the transfer, by planning how to perform the transfer, *e.g.* by moving things that can impede the transfer, and by informing the patient clearly, so that he/she can co-operate during the transfer.

### **Work conditions and modifying factors**

The aim of clustering the identified risk factors was to identify the everyday work conditions that are associated with the risk for injuries (Study V).

The two clusters with an over-representation of injuries contained a combination of persons with full-time work, a rolling schedule and regular patient transfers and they contained a majority of assistant nurses. In both clusters prior injury was associated with an increased risk for injury associated to prior injury.

A comparison with the clusters where there were few injuries indicates that working part-time was a preventive factor for back injury, even when regular patient transfers were included in the work. Previous back injury due to accident was associated with the risk of injury in five of the clusters.

When comparing the differences between the low-risk cluster, where regular patient transfers were performed (cluster 5:4), with the cluster with the highest risk (cluster 5:2), it was found that in the low-risk cluster the nurses worked part-time, half as many worked on a rolling schedule and half as many performed patient transfers alone. All were registered general nurses, without any prior injury and they had been working in nursing for a long time.

The lower injury risk among the registered general nurses who performed patient transfers may thus be a joint effect of shorter working hours and fixed working schedule.

Thus, there is an indication that nurses should have shorter working hours. The aetiology behind the increased risk associated with working hours, rolling schedule and prior back injury need to be further investigated before definite conclusions can be made

## **Methodological considerations**

### *Possible reporting bias*

Compared to statistics from Stockholm County Council in 1989, the numbers of reported over-exertion back accidents were lower than expected during the observation period of Study III-V. The period saw an economic recession in Sweden. The number of health care personnel decreased for the first time, and some nurses might have hesitated to make a claim in this situation. Willingness to report an accident could also differ between the occupational groups. Between 1992 and 1993 the number of registered general nurses working in County Council hospitals decreased by 17%, state enrolled nurses by 6% and assistant nurses by 42% (The Federation of Swedish County Councils, 1992). State enrolled nurses and assistant nurses both have much patient interaction in their work, so the differences in number of claims between the two groups might partly reflect the risk of dismissal.

Changes in the rules concerning workers' compensation during the study period, with stricter requirements regarding approval of the injury as an occupational injury, may also increase the under-reporting.

During the economic recession young people had greater difficulty in entering the labour market than when Study I was performed, at which time statistics for one Swedish county showed that 77% of all those newly employed were 18-24 years of age (Landstingsförbundet, 1986).

In 1992 a sick pay period was introduced in Sweden. After one unpaid day of sick leave, the employer is responsible for compensation during the following 13 days of illness. After this the responsibility for paying cash benefits is transferred to the national health insurance scheme. When the social insurance office provides compensation, they receive information as to whether the illness is believed to be related to work. If so, the office can request a work injury report from the employer. Since 1992, this only applies to cases lasting more than two weeks, which has led to fewer reports of short-term cases, thus mainly affecting accidents (ISA, 1996).

## **The interviews**

Collecting detailed information about the accident process by means of an interview was considered to be a good method (Study III). As each accident is unique it was important to let the nurse give a free description from her point of

view. With supporting questions from the interviewer it was possible to follow the chain of events and factors contributing to the accident process.

A possible source of error could be that the amount of information given in the free description could differ, depending on the nurse's ability and willingness to give very detailed information and on the skill of the interviewer. For example, if the nurse blamed herself she might be reluctant to give information about her part in the event. However, the predominant attitude was very open and several respondents said they were happy that their claims were taken seriously.

### **The selection of cases and referents**

The reason that only nurses working for at least one week during the three months preceding the accident were included in the study was to guarantee that the person had some knowledge of the current work and environment. Thus, none of the accidents occurred during the first six days at work. Statistics from 1985 to 1986 showed that 2% of the accidents among Swedish nurses leading to more than one day of sick leave occurred among persons with less than one week's experience of the job. This inclusion criterion may thus have led to a few reported injuries not being included. Except for cases with less than one week's experience of the job, probably very few, if any, cases were lost of those who reported the accident on an injury form, since the study was performed in direct co-operation with the occupational health care organisation which gets copies of all injury reports.

The fact that the cases had experienced an accident may influence their recall of previous exposure (Rothman & Greenland, 1998). The cases had already described the situation on the injury form once, and, thus, were better equipped, compared to the referents, to remember important factors in the work situation the specific week and this might introduce a recall bias in the study. On the other hand there could also be a recall bias in the opposite direction. For the cases the questions referred to "the week before the over-exertion back injury", whereas the referents were asked about "the last working week". This resulted in a longer time lag for the cases than for the referents. However, most of the variables studied are relatively constant over a longer time span, for which reason any recall bias probably has little effect in the present study.

All who reported an injury, and fulfilled the inclusion criteria, were included, regardless of whether they had been on sick leave or not. The cases were not physically examined, so no information about the severity of the injury was obtained. This might lead to lower relative risk estimates than if only cases with the most severe injuries had been included.

### **Changes in the health care sector**

One consequence of the changes in the health care sector during the study period, due to the recent economic recession, is that a smaller number of persons now share the same amount of work as earlier. Another consequence is that the mean age of nurses is higher today. The combination of fewer nurses, repeated injuries

and increased age also shows the importance of reducing the heavy work load by investing in good transfer devices, making enough space to avoid awkward postures, and having practical on-the-job training on device use, to make it easy and convenient for the staff to use the devices as a matter of course.

### **Contributions to research**

This thesis has contributed to the scientific knowledge regarding over-exertion back injuries due to accidents among nursing personnel by:

- Describing the occurrence of reported occupational accidents leading to over-exertion back injuries among assistant nurses and identifying the place, time of day and situations in which most of these accidents occur.
- Developing instruments for investigation of the accident process and a screening tool for identification of hazards in the physical environment.
- Identifying the most common types of accidents and their patterns of contributing factors to the accident process.
- Identifying work-related and non-work-related risk indicators for reported over-exertion back injuries.
- Identifying the patterns of work-related factors relevant for the risk of back injury and their modifiers.
- Developing a conceptual model, elucidating the different approaches and primary foci within safety research

### **Conclusions**

Assistant nurses have a high relative risk of over-exertion accidents leading to back injuries compared to other Swedish women, and also compared to registered general nurses. The strongest risk indicators for reporting a back injury among nursing personnel were working in an orthopaedic ward, performing regular patient transfers and working full-time. The relative risk of patient transfer was lower among nurses who had received training in how to use the devices on their own ward, and who frequently used transfer devices compared to other nurses.

Several factors contributing to the accident process were identified by the instruments developed in this thesis, and they therefore appear suitable for the investigation of over-exertion back accidents. An important factor was deficiencies in the work environment *e.g.* lack of space or lack of transfer devices. The deficiencies entailed the nurses' performance of patient transfers in a non-optimal way. Most reported accidents occurred during patient transfers in the bed or to/from the bed. During the transfers, which were most often performed without

using transfer devices, the nurse often had to make a sudden intervention, *e.g.* to prevent the patient from falling when the patient suddenly lost his/her balance during the transfer.

Six types of accidents were defined by their pattern of factors contributing to the risk associated with the accident process. The six patterns gave an indication of the complexity of the accident processes.

In addition six homogeneous groups of work conditions and their modifiers were identified. Two of these groups were associated with an increased risk of reported injuries. These groups consisted of a high proportion of nurses working full-time, working on a rolling schedule and performing regular patient transfers. Nurses who had these working conditions were often assistant nurses, and a large proportion of the groups had had a prior injury. The three low-risk clusters were primarily characterised by part-time work, which thus seemed to decrease the risk of performing regular patient transfers.

According to the results in this thesis, the most important measures for prevention of accidents leading to over-exertion back injuries are related to the work organisation, such as working hours, type of schedules, training and instructions. Further, preventive measures directed towards the environment are of greatest importance, for example providing enough space, and also well designed and easily available transfer devices.

# Summary

Engkvist I-L. *Accidents leading to over-exertion back injuries among nursing personnel*. *Arbete och Hälsa* 1999:20.

The overall aim of the present thesis was to contribute to the knowledge of occupational accidents leading to over-exertion back injuries among nursing personnel, which can be used for developing effective preventive strategies. Different combinations of factors and events were assumed to determine the type of accident process leading to an over-exertion injury.

The first study used the Swedish Occupational Injury Register (ISA) to investigate the occurrence of reported accidents leading to back injuries among female assistant nurses in the working population during a two years period. In Study II standardised instruments for the systematic investigation of accidents were developed with the aim to collect the information necessary for effective accident prevention. The third study investigated factors involved in the accident process leading to back injury by using these instruments. Study IV identified and quantified work-related and non-work-related risk indicators for reported back injuries. Study V identified different patterns of risk indicators in the nurses' work situation and factors modifying the risk for back injuries in these situations. The source population was all nurses employed in the Stockholm County hospitals (totally 24,500 persons) and the observed periods were 12 months (Study III) and 36 months (Study IV-V), respectively.

Assistant nurses had a high relative risk of accidents leading to over-exertion back injuries compared to other Swedish women, and also compared to registered general nurses. Most accidents occurred during patient transfer. Several factors contributing to the accident process were identified by the instruments. One important factor was deficiencies in the work environment, *e.g.* lack of space or lack of transfer devices, which entailed the nurse to perform patient transfers in a non-optimal way.

Six types of accidents were defined by their pattern of factors contributing to the risk associated with the accident process.

The strongest risk indicators for reporting a back injury were working in an orthopaedic ward, performing regular patient transfers and working full-time. The relative risk of patient transfer was lower among nurses who had received training in how to use the devices on their own ward, and who frequently used transfer devices. Further, six homogeneous groups of work conditions and their modifiers were identified, two of which were associated with an increased risk. These groups consisted of a high proportion of assistant nurses working full-time, on a rolling schedule and regularly performing patient transfers. A large proportion of the groups had had a prior injury. The three low-risk clusters were primarily characterised by part-time work.



According to the results in this thesis, the most important measures for prevention of accidents leading to over-exertion back injuries are related to the work organisation and measures directed towards the environment.

Keywords: accident investigation, back injury, cluster analysis, epidemiology, ergonomics, interview, nurse, patient transfer, physical environment, work organisation.

# Sammanfattning (summary in Swedish)

Engkvist I-L. *Olyckor vilka lett till överbelastningsskador i rygg bland sjukvårdspersonal*. Arbete och Hälsa 1999:20.

Det övergripande syftet med denna avhandling var att öka kunskapen om uppkomst av olyckor, vilka leder till ryggskador genom överbelastning bland sjukvårdspersonal. Olika kombinationer av faktorer och händelser antogs bidra till en olycksfallsprocess vilken leder till en skada i rygg på grund av överbelastning.

Syftet med den första studien (Studie I) var att beräkna den kumulativa incidensen av rapporterade olyckor som lett till ryggskador genom överbelastning bland samtliga sjukvårdsbiträden och undersköterskor i Sverige under två år. Studien baserades på rapporterade arbetsskador i ISA registret (Informationssystemet för arbetsskador).

En ny metod för olycksfallsutredning, med syfte att finna preventiva åtgärder, utarbetades i samarbete mellan forskare och praktiker (Studie II). Standardiserade instrument för en systematisk olycksfallsutredning arbetades fram bestående av två intervjuformulär, ett för den olycksdrabbade och ett för arbetsledaren samt en ergonomisk checklista för identifiering av risker i den fysiska arbetsmiljön.

Syftet med den tredje studien var att identifiera faktorer som bidragit vid olycksfallsprocessen med hjälp av de två intervjuformulären och den ergonomiska checklistan. I Studie IV var syftet att identifiera och kvantifiera arbets- och icke arbetsrelaterade riksindikatorer för rapporterade överbelastningsskador i rygg p.g.a. olycka. Syftet i Studie V var att identifiera olika mönster av de funna riskindikatorerna i arbetssituationen och att identifiera hur olika individfaktorer påverkade risken i dessa arbetssituationer. Studiebasen bestod av sjukvårdsbiträden, undersköterskor och sjuksköterskor anställda inom Stockholms läns landsting, totalt c:a 24 500 personer. Studieperioden var 12 månader (Studie I) respektive 36 månader (Studie IV-V).

Undersköterskor och sjukvårdsbiträden hade en hög relativ risk för skada pga olycksfall jämfört med övriga förvärvsarbetande kvinnor i Sverige, och även jämfört med sjuksköterskor. De flesta olyckorna uppstod vid patientförflyttning. Flera faktorer som medverkade vid olycksfallsprocessen identifierades via de framtagna instrumenten. Sex typolyckor och deras respektive mönster av bidragande faktorer identifierades genom klusteranalys. En viktig faktor var brister i den fysiska arbetsmiljön, t.ex. att det var trångt eller att det saknades förflyttningshjälpmedel, vilka ofta tvingade vårdaren att arbeta på ett riskfyllt sätt.

De starkaste riskindikatorerna var att arbeta på en ortopedklinik, att regelbundet utföra patientförflyttningar och att arbeta heltid. Den relativa risken för skada vid patientförflyttning var lägre bland dem som fått träning i användande av förflyttningshjälpmedel på den egna avdelningen samt de som regelbundet använde förflyttningshjälpmedel jämfört med övriga.

Sex olika mönster av de funna riskindikatorerna, och deras modifierande individfaktorer, i arbetssituationen identifierades. Två av dessa grupper uppvisade en överrisk för skada. Dessa kännetecknades av en hög andel undersköterskor och sjukvårdsbiträden som arbetade heltid, arbetade på rullande schema och regelbundet förflyttade patienter. Vidare hade en stor andel av personerna drabbats av ryggskada i arbetet tidigare.

Resultaten i denna avhandling pekar på att de mest angelägna preventiva åtgärderna bör riktas mot organisatoriska förhållanden t.ex. arbetstid och schemaläggning samt mot den fysiska arbetsmiljön. Exempel på åtgärder i den fysiska miljön är ökat utrymme speciellt runt sängar och i toalettutrymmen samt fler och lättanvända förflyttningshjälpmedel.

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