

Use and Effect of Ergonomic Devices in Healthcare

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Use and Effect of Ergonomic Devices in Healthcare

**Gebruik en effect van ergonomische hulpmiddelen
in de gezondheidszorg**

Proefschrift

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Chapter



General introduction





1. GENERAL INTRODUCTION

1.1. Low back pain

Musculoskeletal disorders (MSD) have a high prevalence with over 75% of the Dutch adults reporting one or more complaints in the past 12 months.¹ In a large population-based study back pain was most prevalent (44%), followed by complaints of neck (31%), shoulder (30%), and arms (23%). The high occurrence of MSD has large economical consequences, due to substantial healthcare utilisation, sickness absence, and permanent disability. About 25% of persons with MSD will take a sick leave and in about 20% of these cases the duration of sick leave will exceed 4 weeks.²

In the healthcare sector the prevalence of MSD and associated consequences is higher than in most occupations.³ The most common musculoskeletal disorder among nurses is low back pain.⁴⁻⁹ A significant proportion of low back pain (LBP) episodes can be attributed to events that occur during patient handling activities.^{4, 10-13} Nurses are exposed to lifting during transferring patients, awkward working postures during patient care, and pushing and/or pulling during repositioning of patients or manoeuvring equipment. These activities have been reported as a cause of back complaints.^{6, 13-15} Smedley et al., for example, found that patient repositioning and patient transfers from bed to chair were associated with an increased risk of LBP.⁶

1.2. Primary preventive interventions

A wide range of primary preventive interventions have been developed in the past years to reduce the exposure to mechanical load related to patient handling in order to (partly) decrease the occurrence of back complaints. A number of laboratory studies have demonstrated the efficacy of these primary preventive interventions designed to reduce exposure to mechanical load.¹⁶⁻¹⁹ Zhuang et al. found that different types of lifting devices reduced spinal loads by two-third.¹⁹ However, workplace studies have difficulties showing the effectiveness of primary preventive interventions in reducing the occurrence of back complaints.²⁰⁻²¹ Contradictory results have been found for engineering interventions, such as lifting devices.^{20, 22} There is strong evidence that personal interventions alone, such as training on preferred patient handling techniques, are not effective.^{21, 23} Either these techniques did not reduce the risk of back injury or the training did not lead to an adequate change in lifting and handling techniques.²³ Administrative interventions, targeting work practices and policies, are often an integral part of a more comprehensive intervention. There is moderate evidence for the effectiveness of multidimensional interventions, which have been applied more often recently.²⁰⁻²¹ The difficulties that intervention studies are experiencing in showing the effectiveness of primary preventive interventions in reducing the occurrence of low back pain might be partly explained by the limited follow-up period of the intervention studies relative to the time period needed to cause a noticeable decrease in the incidence of low back pain. Given

the fact that it may take several years to develop back complaints, consequently a reduction in mechanical load will not immediately result in an improvement in the occurrence of back complaints. The follow-up period after the intervention should reflect the latency period needed to develop back complaints.²⁴

1.3. Ergocoach

In the past few years in the Netherlands incentive policies have been enacted in the so-called 'arbo-convenanten', national agreements on improvement of working conditions in specific branches. In healthcare organisations primary preventive interventions have been introduced, eg specific work training (eg lifting techniques), ergonomic devices (eg lifting hoists, gliding sheets), and rapid self-appraisal methods for the evaluation of mechanical load (eg the lifting-thermometer). Despite these initiatives and financial incentives, the timely and integrated implementation remains difficult. The healthcare branch has, therefore, developed a new implementation strategy, including the presence of 'ergocoaches'. In short, an ergocoach (also called peer leaders and back injury resource nurses) is a person trained and specialized in ergonomic principles who works on a ward like any other nurse.²⁵⁻²⁶ An ergocoach is responsible for starting and maintaining the process of working according to ergonomic principles by being available for questions of colleagues, identifying problems with and conducting assessments of mechanical load, contributing to workplace improvements, and training of personnel.²⁷ The rationale behind this concept is that a regular member of a team will enhance implementation due to speaking the 'same language', creating a trust-worthy environment, being easily accessible for questions and advice, and supporting a bottom-up approach.

There is little insight in whether ergocoaches are successful in contributing to a better implementation of ergonomic devices at the workplace and whether the presence of an ergocoach is changing the behaviour of co-workers with regard to ergonomic devices use.

1.4. Implementation of primary preventive interventions

At the workplace the results of the primary preventive interventions will depend not only on the effectiveness of the intervention itself, but also on the appropriate implementation of this intervention in the actual work situation.²⁸ Grol and Grimshaw have emphasized the importance of different steps to be taken in the implementing process of an intervention.²⁹ An important step in the implementation process is the identification of obstacles to change work practices, which may arise at the level of the individual person as well as the wider environment.²⁹ Individual factors refer to the variables within the person, such as motivation, attitude, and a person's belief in his or her ability to use the intervention.³⁰ Environmental factors refer to the social and physical context in which a person needs to function.³¹⁻³³ Several barriers and facilitators to effective implementation have been identified in intervention studies. Nelson et al. for example, described several barriers in the implementation of patient



handling devices, such as difficulty to use, time constraints, patient aversion and inadequate number of available lifting devices.³⁴ Another study reported, among other things, lack of knowledge and lack of policy of mandatory lift usage as barriers in the implementation of lifting devices.³² Although several barriers in the implementation of patient handling devices have been identified in intervention studies, there is little insight into their impact on the effectiveness of these interventions.^{28, 35-36} This requires quantitative evaluation of the influence of these factors on the effectiveness of primary preventive interventions.

1.5. Implementation models

Many implementation models have been developed, such as the Bandura's social cognitive theory, the innovation diffuse theory, and the social influence theory.³⁷⁻³⁹ Since obstacles to change work practices can arise at the level of the individual person as well as the wider environment, a theoretical implementation model is valuable for the identification of barriers and facilitators in the implementation process of primary preventive interventions. Barriers are defined as factors that hamper the adequate implementation of primary preventive interventions. Facilitators are defined as factors that enhance the adequate implementation of primary preventive interventions. In this thesis, two approaches are used to identify barriers and facilitators in use of primary preventive interventions in healthcare, aimed at reducing mechanical load during patient handling activities. Both approaches aim at individual as well as environmental factors and are closely intertwined, but put a different emphasis on these factors. The first approach has been proposed by Rothschild who defines three broad categories of determinants and is oriented towards individual factors.⁴⁰ Whereas the second approach has been presented by Shain and Kramer, specifically addressing implementation of healthcare interventions at the workplace and further specifying the determinant categories of Rothschild, primarily focusing on the environmental context.⁴¹

Rothschild has defined three categories of determinants: motivation, ability, and opportunity (table 1).⁴⁰ Motivation is the willingness of individuals to undertake the necessary actions to commit to the intervention. Ability refers to the capability of individuals to do something that requires specific skills, knowledge, experience, and attitude. Opportunity relates to the environment in which the intervention is implemented and was further specified by Shain and Kramer.⁴¹ They have distinguished social support, management support, supportive management climate, convenience and easily accessible, interactivity, wide appeal, employee participation, and self-efficacy (table 1). Employee participation and self-efficacy are individual factors and also included in the categories of Rothschild. Social support embraces the supportiveness of family, friends, co-workers, and others to the intervention. Convenience of use and easily accessibility relates to the availability of resources such as enough time to transfer patients, enough lifting devices, and stable staff. Management support includes the commitment of employers to the intervention. Supportive management climate refers to a work situation where the intervention is being promoted rather than defeated. Wide

Table 1 Definitions of the determinant categories of Rothschild and Shain and Kramer.

Type of barrier and facilitator and source	Category
1. Individual (Rothschild et al. 1999) (40)	Motivation: willingness of individuals to undertake the necessary actions to commit to the intervention Ability: capability of individuals to do something that requires specific skills, knowledge, experience, and attitude
2. Environment (Shain and Kramer 2004) (41)	Social support: supportiveness of family, friends, co-workers, and others to the intervention Convenience and easily accessible: availability of resources such as enough time to transfer patients, enough lifting devices, stable staff, etc Management support: commitment of employers to the intervention Supportive management climate: organisation of work in ways that promote rather than defeat the intervention Wide appeal: attractiveness of the intervention to a wide variety of workers Interactivity: reinforcement of the intervention by other work practices

appeal is the attractiveness of the intervention to a wide variety of workers. Interactivity covers the reinforcement of an intervention by other work practices. In healthcare, the patient is an additional important environmental factor, encompassing the physical and cognitive capabilities of the patients, as well as the attitudes of the patients towards the intervention.³²

Since many intervention studies have difficulties to implement the interventions effectively, it is important to acquire a good understanding of the problem, its setting, and the obstacles to change in order to develop more effective strategies for change. It is important to understand the factors that facilitate or hinder change in practice. These implementation models may be used to explain the success or failure of implementation of an intervention. They are useful for identifying potential barriers and facilitators in order to gain more knowledge of which factors are decisive in achieving targetted changes.

2. OBJECTIVES OF THIS THESIS

Various ergonomic devices, such as lifting devices and sliding sheets, have been implemented in healthcare. Intervention studies have difficulties showing the effectiveness of these ergonomic devices.²¹ It is, therefore, important to determine whether mechanical load, as important risk factor for occurrence of back complaints, can be reduced by ergonomic devices use. Therefore, the first objective of this thesis is:

1. To estimate the effect of ergonomic devices on mechanical load and to assess the compliance of use of these devices during patient handling activities in healthcare.



Since the compliance of ergonomic devices is essential for the effectiveness of ergonomic devices, it is important to consider factors influencing the compliance of ergonomic devices. Several factors, individual as well as organisational, could influence compliance. Therefore, the second objective of this thesis is:

2. To determine the influence of individual and organisational factors on the appropriate use of ergonomic devices during patient handling activities in healthcare.

The fact that workplace studies have difficulties showing the effectiveness of ergonomic interventions might be partly explained by the lack of sufficiently long follow-up periods of intervention studies as well. A reduction in mechanical load during patient handling activities will take some time before a change in the occurrence of low back pain can be noted. Hence, these long-term consequences must be assessed in an exposure-disease model that links mechanical load to the occurrence of low back pain over time. Health impact assessment is a method to assess the potential long-term effects of ergonomic devices use on the occurrence of low back pain of a population. The third objective of this thesis is:

3. To estimate the long-term effects of lifting devices use during transfer activities with patients on the occurrence of low back pain among nurses in healthcare.

3. STUDY POPULATION

The studies in this thesis are based on data collected in healthcare organisations in the Netherlands and on a health impact assessment model. Data was collected in 19 nursing homes and 19 hospitals between 2007 and 2009. Organisations with a structured patient handling programme including the presence of ergocoaches at the ward were included. Data was gathered at 3 different levels; the organisation, the ward, and the individual nurse. At the organisational level, institutional characteristics and policies were collected by means of a self-administered questionnaire filled out by the manager. At the level of the ward, ward characteristics and policies were collected by means of a self-administered questionnaire filled out by the team leader of the ward, activities of the ergocoach was gathered through a self-administered questionnaire for ergocoaches. Individual nurses were observed real time while performing patient handling activities and interviewed afterwards to collect additional information on individual characteristics and establish their individual behaviour with regard to ergonomic devices use during patient handling activities. For selected wards within each institute a checklist was completed by researchers during a walk-through survey of wards and patient's rooms on technical facilities and information was obtained on number of patients, number of nurses, and number of ergocoaches.

For the health impact assessment model a systematic review was conducted on the exposure profile of nurses during patient handling activities, the occurrence of low back pain among nurses, the population attributable fraction of patient handling activities to low back pain, and the reduction in mechanical load due to use of ergonomic interventions during patient handling activities.

4. OUTLINE OF THIS THESIS

This thesis is divided into three parts. Part 1 focuses on the effects of ergonomic devices use during patient handling activities on the exposure to mechanical load and compliance of use of these devices during patient handling activities. Part 2 focuses on barriers and facilitators in the implementation of ergonomic interventions on patient handling in healthcare. In Part 3 the long-term effects of the use of lifting devices on the occurrence of low back pain is estimated.

Part 1

Chapter 2 will focus on the first objective of this thesis, i.e. the effect of ergonomic devices use during patient handling activities on the exposure to mechanical load and the compliance of use of these devices during patient handling activities. Chapter 2 presents a cross-sectional study evaluating the required and actual use of ergonomic devices during patient handling activities and the effect of these devices on reduction of mechanical load during patient handling activities in 17 nursing homes.

Part 2

Chapters 3 to 5 will address the second objective of this thesis, i.e. the influence of individual and organisational factors on the implementation of ergonomic devices in healthcare. Chapter 3 is a systematic review regarding barriers and facilitators during the implementation of primary preventive interventions on patient handling in healthcare and the influence of these barriers and facilitators on the effectiveness of these interventions. Chapter 4 presents a cross-sectional study assessing the influence of individual and organisational factors on ergonomic devices use during patient handling activities in healthcare in 19 nursing homes and 19 hospitals. Chapter 5 evaluates the influence of individual and organisational factors on nurses' behaviour to use lifting devices during transfer activities with patients in healthcare. The studies in chapters 4 and 5 have the same study population..

Part 3

Chapter 6 will focus on the third objective of this thesis, i.e. the long term effects of lifting devices use during transfer activities with patients on the occurrence of low back pain among

nurses. Chapter 6 estimates the long term consequences of lifting devices use during transfer activities with patients on the occurrence of low back pain among nurses in a health impact assessment model (HIA). This model was developed to extrapolate the results of intervention studies in a hypothetical cohort of nurses with life-long follow-up.

Finally, chapter 7 discusses the main findings of the previous chapters and presents recommendations for future research.



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PART



MECHANICAL LOAD AND ERGONOMIC DEVICES

Chapter



The influence of ergonomic devices on mechanical load during patient handling activities in nursing homes

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ABSTRACT

Objectives Mechanical load during patient handling activities is an important risk factor for low back pain among nursing personnel. The aims of this study were to describe required and actual use of ergonomic devices during patient handling activities and to assess the influence of these ergonomic devices on mechanical load during patient handling activities.

Methods For each patient, based on national guidelines, it was recorded which specific ergonomic devices were required during distinct patient handling activities, defined by transferring a patient, providing personal care, repositioning patients in the bed, and putting on and taking off anti-embolism stockings. During real-time observations over 60 h among 186 nurses on 735 separate patient handling activities in 17 nursing homes, it was established whether ergonomic devices were actually used. Mechanical load was assessed through observations of frequency and duration of a flexed or rotated trunk >30° and frequency of pushing, pulling, lifting or carrying requiring forces <100 N, between 100 and 230 N, and >230 N from start to end of each separate patient handling activity. The number of patients and nurses per ward and the ratio of nurses per patient were used as ward characteristics with potential influence on mechanical load. A mixed-effect model for repeated measurements was used to determine the influence of ergonomic devices and ward characteristics on mechanical load.

Results Use of ergonomic devices was required according to national guidelines in 520 of 735 (71%) separate patient handling activities, and actual use was observed in 357 of 520 (69%) patient handling activities. A favourable ratio of nurses per patient was associated with a decreased duration of time spent in awkward back postures during handling anti-embolism stocking (43%), patient transfers (33%), and personal care of patients (24%) and also frequency of manually lifting patients (33%). Use of lifting devices was associated with a lower frequency of forces exerted (64%), adjustable bed and shower chairs with a shorter duration of awkward back postures (38%), and an anti-embolism stockings slide with a lower frequency of forces exerted (95%).

Conclusions In wards in nursing homes with a higher number of staff less awkward back postures as well as forceful lifting were observed during patient handling activities. The use of ergonomic devices was high and associated with less forceful movements and awkward back postures. Both aspects will most likely contribute to the prevention of low back pain among nurses.

INTRODUCTION

The most common musculoskeletal disorder among nurses is low back pain.¹⁻⁶ A significant proportion of back pain episodes can be attributed to patient handling activities.^{1,4,7-10} Nurses manually lift patients during transfers, adopt awkward postures during patient care, and push or pull during repositioning of patients or manoeuvring equipment. These activities with awkward back postures and high exerted forces have been reported as causes of back complaints.^{6,10-12} Smedley et al., for example, found that repositioning patients and transfers of patients from bed to chair were associated with an increased occurrence of low back pain.⁶

Various ergonomic devices have been developed in the past years to reduce mechanical load during patient handling activities in order to prevent the occurrence of back complaints. Several laboratory studies have demonstrated the efficacy of these ergonomic devices during experiments.¹³⁻¹⁶ Zhuang et al., for example, showed that different types of lifting devices reduced spinal compression forces by two-thirds.¹⁶ However, intervention studies at the workplace have difficulties showing the effectiveness of ergonomic devices in reducing the occurrence of back complaints.¹⁷ A recent systematic review concluded that there is only moderate evidence for the effectiveness of multicomponent patient handling interventions, including appropriate lift or transfer equipment to reduce mechanical loads.¹⁸ At the workplace, the results of the ergonomic interventions will depend not only on the efficacy of the intervention itself but also on the appropriate implementation of this intervention in the actual work situation.^{19,20} It is, therefore, important to study the actual use of lifting aids during patient handling activities and to determine their effect on mechanical load among nurses.

In the Netherlands, national guidelines in healthcare prescribe the use of different ergonomic devices during specific patient handling activities. For example, a lifting device is required during transfers of patients who need assistance in movements. These guidelines facilitate structured patient handling programmes in healthcare organizations with the overall aim to reduce mechanical load at work. Although these guidelines are not legally binding, they form an essential part of the self-regulatory mechanism within the healthcare sector in order to reduce strenuous working conditions. Since compliance to these guidelines is not expected to be perfect, this development offers interesting opportunities to study differences in mechanical load during patient handling in nursing homes according to required use, actual use, and non-use of available ergonomic devices. Therefore, the aim of this study was to describe the required and actual use of ergonomic devices during patient handling activities and to assess the influence of these devices on mechanical load during patient handling activities.



METHODS

Study population

The present cross-sectional study took place in 17 nursing homes with a structured patient handling programme. This programme centered around the presence at each ward of an ergocoach. This is a person trained and specialized in ergonomic principles who is responsible for supporting the process of working according to ergonomic principles in his ward. Their activities include being available for questions from colleagues, identifying problems, contributing to workplace improvements, and training personnel. In total, 37 nursing homes were approached with written information about the study purpose with a supportive letter of the national organization in the healthcare sector responsible for training and support of ergocoaches. A subsequent visit was paid to each organization in order to explain aims and time constraints of the study in more detail. Eventually, 17 nursing homes (response 46%) decided to participate. Primary reasons for non-participation were lack of time, merger of the facility, and construction work in the facility.

In the Netherlands, there are two types of nursing homes. Firstly, the home which is destined for longterm care for elderly who are not able to live entirely independent ($n=10$). The home for elderly provides general support for uncomplicated nursing care for physical, psychogeriatric, or psychosocial problems as a result of old age. Secondly, the home that is intended for people who need specific nursing care, residential care, or revalidation as a result of disease, disorder, or old age but no longer need specialized medical care in a hospital ($n=7$).

The data collection was carried out between 2007 and 2009. Individual nurses ($n=186$) were observed while performing patient handling activities. At the organisational level, ward characteristics policies were collected by means of a self-administered questionnaire filled out by the team leader of the ward (response 67 of 69). The number of nurses, the number of patients, and the ratio of (full-time equivalent) nurses per patient at ward level were regarded as potential determinants of mechanical load. A ratio above the median value of 0.6 was interpreted as a favourable ratio of nurses per patient. Individual characteristics of nurses, such as age, gender, work experience, and presence of back complaints and any musculoskeletal complaints were collected by interview.

Informed consent was obtained verbally from all nursing homes and nurses prior to the study in accordance with the requirements for non-identifiable data collection in the Dutch Code of Conduct for Observational Research (www.federa.org).

Observations at the workplace

Real-time observations at the workplace were conducted to evaluate the actual use of ergonomic devices during patient handling activities and to assess the influence of ergonomic devices on mechanical load during these activities. Four patient handling activities were

defined: (i) transferring a patient, for example from bed to chair, (ii) personal care, like washing and dressing a patient, (iii) repositioning patients in the bed, like turning a patient and moving the patient up in bed, and (iv) putting on and taking off anti-embolism stockings.

The procedure of the workplace survey started with a separate introduction at each ward to seek permission of team leaders and nurses involved. Researchers visited each ward during the periods with most patient handling activities, primarily the first two hours of the morning shift between 07.00 and 09.00 hrs and the first hour after lunch between 12.00 and 13.00 hrs. Observations took place only during patient handling activities. Within each ward, all nurses present were selected for participation and informed that data collection was completely anonymous. All nurses who were invited to contribute to the study gave the required verbal informed consent. Observations would start with the first nurse handling a particular patient and end after all nursing activities with that patient were finished. Subsequently, the same nurse was followed to a second patient when patient handling activities were expected to occur or otherwise, a second nurse was observed during handling of another patient. In total, 186 nurses performed 735 separate patient handling activities. About 56% of the nurses were observed once during a specific patient handling activity, and 44% of the nurses were observed repeatedly during specific patient handling activities within the same patients and with different patients.

The observations with a hand-held computer and structured software²¹ were performed by two researchers, both educated and experienced in observing human movements. The researchers rated the use of ergonomic devices and different characteristics of mechanical load during patient handling activities according to a strict protocol. The whole procedure was pretested among 31 nurses in two nursing homes that were not included in this study. The inter-rater agreement for non-neutral trunk posture was high (Pearson correlation $r=0.72$) and moderate for pushing and pulling ($r=0.36$) and lifting ($r=0.26$). After this pilot, reasons for disagreement were discussed and the observation protocol was tightened.

Use of ergonomic devices

The national guidelines prescribe the type of ergonomic device to be used during different patient handling activities; lifting devices for transferring a patient, an electric adjustable bed and an adjustable shower chair during personal care, such as washing and dressing, an electric adjustable bed and a slide sheet for repositioning a patient in bed, and a compression stocking slide for putting on and taking off anti-embolism stockings.²² These guidelines combine the level of functional mobility of the patients with specific activities during handling patients. In general, ergonomic devices are required for patients who are able to assist and contribute actively but unable to perform the activity on their own, and patients who are passive with no or very little contribution to the required movements. A stocking slide should always be used for putting on and taking off anti-embolism stockings of a patient.²³



The required use of ergonomic devices was retrieved from the personal care file of each patient. In absence of this information, nurses were asked to provide additional information. Before the observations at the workplace, the researcher collected information on the required use of ergonomic devices. Subsequently, during the observations of patient handling activities, the actual use of these ergonomic devices was registered.

Quantitative assessment of mechanical load

The real-time observations registered four measures of mechanical load: duration of trunk flexion or rotation over 30° (% work time with non-neutral trunk posture) and frequency of pushing, pulling, lifting or carrying requiring forces below 100 N, between 100 and 230 N, and over 230 N.

An awkward back posture was defined by at least 30° of flexion or rotation of the trunk, based on an extensive survey showing that postural patterns between nurses and other occupations differed most strongly above this value²⁴ and on the definition of awkward back postures agreed upon in the national guidelines.²²

For each patient handling activity that required a forceful movement, studies were identified that presented actual measurements of the forces applied during corresponding patient handling situations from volunteer participants or healthcare workers, primarily in a laboratory set-up.^{11, 13, 14, 16, 25, 26} Acknowledging substantial differences in measurements of sustained forces during patient handling, this information guided the assessments of the authors to classify each activity within the categories <100 N, 100-230 N, and > 230 N. For example, the forces exerted for turning a patient in bed was set between 100 and 230 N without a sliding sheet¹⁶ and less than 100 N with the appropriate use of a sliding sheet.¹⁴ Incorrect use of ergonomic devices and resistance of patients resulted in higher assessment of exerted forces. The lower limit of less than 100 N reflects current guidelines for manual handling²⁷ and the upper limit was adopted from the well-established National Institute of Occupational Safety and Health (NIOSH) equation for lifting of loads.²⁸

Data analysis

Since mechanical load may vary at different levels within nursing homes, a nested analysis of variance was used to calculate the proportion of variance due to nursing homes, wards within the nursing homes, individual nurses within the wards, and patient handling activities observed nurses.

A linear mixed-effect model for repeated measurements was used to analyse the effect of ergonomic devices on mechanical load during patient handling activities, adjusted for individual and organisational factors and inter-observer variation. The analyses were performed for each category of patient handling activity separately. The distributions of the measures of mechanical load during each category were evaluated and differed significantly from the normal distribution. Therefore, simple log-transformations were performed which mark-

edly reduced the skewness of the distributions of exposure variables within each patient handling activity. The organisational factors obtained from wards and the observers were included in the mixed-effect model as fixed (categorical) effects. The variances between and within nurses were regarded as random effects. Variance in exposure within a nurse may be due to factors such as patients' characteristics and differences in lifting aids. The variances between and within nurses were pooled across all determinants of exposure and assumed equal across all fixed determinants. This assumption of a compound symmetry covariance structure, resulting in the most restrictive error structure possible, was chosen because of the relatively few measurements available for some determinants, which limited the number of parameters that could be estimated in the model.²⁹ For the mixed-effect models, this assumption on error structure was not violated against tests of significance for change in the goodness-of-fit. Given the fact that the potential determinants of mechanical load were inter-related, the first step in the analysis was a separate mixed-effect model for each parameter of mechanical load. The determinant that had the largest reduction in the overall variance was first retained in the second step. Other determinants were subsequently stepwise introduced into the mixed-effect model and evaluated for their improvement in goodness-of-fit. A determinant was included in the final model when introducing a change of at least 10% in other determinants, independent of their level of significance. Given the purpose of the study, the use of an ergonomic device was introduced in the final model by default, independently of its level of statistical significance. The Akaike information criterion (AIC) was used as measure of the overall fit of the model and additional determinants were retained in the mixed-effect model when resulting in a significant improvement in the overall fit. The AIC was used instead of the more conventional two-log likelihood measure since the AIC attempts to find a model that best explains the data with a minimum of parameters. The regression coefficient of each determinant in the mixed model reflects observed differences in mechanical load. Since these regression models are based on logtransformed exposure data, the coefficient must be converted by the natural power before it expresses the reduction in exposure. This was defined as the reduction in exposure factor (REF). All analyses were conducted using the procedure Proc Mixed in SAS version 6.12 software (SAS Institute, Cary, NC, USA).

RESULTS

The study population consisted predominantly of women, ranging in age from 16 to 62 years (Table 1). The average working experience of the nurses was 8 years. Organisations differed considerably with respect to number of wards and number of patients per ward. The ratio of full time equivalent nurses per patient per ward ranged from 0.1 to 3.3, influenced largely by patients' characteristics.



Table 1 Organisational and ward characteristics of the nursing homes (n=17) and individual characteristics of the nurses (n=186).

Characteristics	Nursing homes
Nursing homes	n=17
Number of wards per organisation, median (range)	4 (1-12)
Workers (full-time equivalent) per organisation, median (range)	112 (26-400)
Patients per organisation, median (range)	126 (58-320)
Wards within nursing homes	n=69
Patients per ward, median (range)	30 (10-74)
Nurses (full-time equivalent) per ward, median (range)	14 (4-62)
Ratio full-time equivalent nurse/patient per ward, median (range)	0.6 (0.1-3.3)
Individual characteristics of nurses	n=186
Age, years, mean (SD)	38 (13)
Gender, female %	96
Working experience (years), median (range)	8 (0-43)
Back complaints in the past 12 months (%)	42
Any musculoskeletal complaints in the past 12 months (%)	60

Table 2 provides information of 735 separate patient handling activities performed by 186 nurses with a total duration of 3399 min. An ergonomic device was required according to the national practical guidelines in 520 of 735 patient handling activities. The actual use of ergonomic devices was 69%, ranging from 14% use of sliding sheets to 85% use of electric adjustable beds for repositioning of patients within bed.

Table 2 Characteristics of quantitative assessment of mechanical load and ergonomic devices used during patient handling activities.

Category of activity	Devices	H	W	N	n	Total duration (min)	Necessity of use of a device	Actual use of a device (%)
Transfer activity with patient	Lifting devices	17	68	171	265	812	196	142 (72)
Personal care of patients (A)	Electric adjustable bed	17	58	99	144	1255	120	109 (91)
Personal care of patients (B)	Adjustable shower chair	17	37	59	81	1065	32	16 (50)
Repositioning patients within the bed (C)	Slide sheet	14	51	101	148	170	115	16 (14)
Repositioning patients within the bed (D)	Electric adjustable bed	14	51	101	148	170	115	98 (85)
Putting on and taking off anti-embolism stockings	Elastic compression slide	16	33	40	57	97	57	35 (61)
Total		17	69	186	735	3399	520	357 (69)

H, number of nursing homes; W, number of wards; N, number of nurses; n, number of observations. A, use of electric adjustable bed; B, use of adjustable shower chair; C, use of slide sheet; D, use of electric adjustable bed.

Table 3 shows that the actual use of ergonomic devices decreased awkward back postures as well as forces exerted in all categories of patient handling activities, except for the use of an electric adjustable bed during personal care of a patient and repositioning a patient within the bed. The actual use of lifting devices reduced the frequency of forces over 230 N with 86% (from 11.1 to 1.6) and the actual use of a compression stocking slide reduced the frequency of forces between 100 and 230 N with 98% (from 93.2 to 1.8). The mean duration

Table 3 Awkward back postures (percentage of work time) and forces exerted (frequency per hour) among personnel in nursing homes, stratified by patient handling activities.

Category of activity	Devices use	N	D	Non-neutral trunk posture ^a	Forces exerted	Forces exerted
				(% of work time)	100-230N (frequency/h)	>230N (frequency/h)
Transfer activity with patient	Not necessary	69	125	9.3	15.8	1.9
	Necessary and not used	54	114	16.7	26.9	11.1
	Necessary and used	142	573	16.5	8.8	1.6
Personal care of patients (A)	Not necessary	24	175	19.7	0.7	0.3
	Necessary and not used	11	84	20.4	0.7	0.7
	Necessary and used	109	996	19.7	5.5	0.5
Personal care of patients (B)	Not necessary	49	680	24.2	0.2	0.2
	Necessary and not used	16	183	28.8	5.2	1.3
	Necessary and used	16	202	28.3	4.2	0.6
Reposition patients within the bed (C)	Not necessary	33	22	19.0	71.9	5.5
	Necessary and not used	99	115	29.5	97.4	9.4
	Necessary and used	16	34	13.5	84.0	3.6
Reposition patients within the bed (D)	Not necessary	33	22	19.0	71.9	5.5
	Necessary and not used	17	28	20.9	87.6	8.5
	Necessary and used	98	120	27.0	96.0	8.0
Putting on and taking off anti-embolism stockings	Necessary and not used	22	29	43.1	93.2	0.0
	Necessary and used	35	68	33.7	1.8	0.0

N, number of measurements; D, total duration of patient handling activity (min); A, use of electric adjustable bed; B, use of adjustable shower chair; C, use of slide sheet; D, use of electric adjustable bed.

^a Non-neutral trunk posture is >30° trunk flexion and/or >30° trunk rotation.

of patient handling activities when using an ergonomic device increased 10%-91%, except for repositioning a patient in bed where the use of a sliding sheet reduced the duration of activity substantially.

The largest source of variance in mechanical load was within-nurses, ranging between 21 and 95% (Table 4). The organisations and the wards within the organisations hardly contributed to the total variability in mechanical load.

Table 5 indicates that the actual use of required ergonomic devices was an important determinant of mechanical load in all categories of patient handling activities and the ratio nurses per patient at the ward was an important determinant of mechanical load in the categories transfer of patients and putting on and taking off anti-embolism stockings. The use of ergonomic devices had less mechanical load, especially less frequent exertion of forces, with REFs ranging between 1.6 and 22.0. Converting these REFs into exposure differences, use of lifting devices had a 64% lower frequency of forces exerted, adjustable bed and shower chairs a 38% decrease in duration of awkward back postures, and an anti-embolism stockings slide a 95% lower frequent of forces exerted. The use of ergonomic devices explained up to 60% of the variance within nurses. A favourable ratio of nurses per patient at the ward was associated with less awkward back postures (REFs between 1.3 and 1.7) and lower frequency of forces (REF 1.5). Hence, a higher ratio of nurses per patient was associated with less time

Table 4 Estimated contribution of different sources of variance to the total variability in mechanical load due to trunk flexion or rotation and forces exerted.

Category of activity	Mechanical load	Sources of variance			
		Between organisations, %	Between wards within organisations, %	Between nurses within wards, %	Within nurses, %
Transfer activity with patient	Non-neutral trunk posture	11	5	3	81
	Forces exerted 100-230N	16	0	0	84
	Forces exerted >230N	9	1	7	83
Personal care of patients (A)	Non-neutral trunk posture	6	18	32	45
	Forces exerted 100-230N	2	10	9	79
	Forces exerted >230N	5	0	0	95
Personal care of patients (B)	Non-neutral trunk posture	9	25	45	21
	Forces exerted 100-230N	0	0	16	84
	Forces exerted >230N	0	0	.	0
Repositioning patients within the bed (C)	Non-neutral trunk posture	2	13	9	76
	Forces exerted 100-230N	0	16	28	57
	Forces exerted >230N	2	0	12	86
Repositioning patients within the bed (D)	Non-neutral trunk posture	2	13	9	76
	Forces exerted 100-230N	0	16	28	57
	Forces exerted >230N	2	0	12	86
Putting on and taking off anti-embolism stockings	Non-neutral trunk posture	0	44	0	56
	Forces exerted 100-230N	7	25	0	68
	Forces exerted >230N	0	0	0	0

A, use of electric adjustable bed; B, use of adjustable shower chair; C, use of slide sheet; D, use of electric adjustable bed.

spent in awkward back postures during handling anti-embolism stocking (43%), patient transfers (33%), and personal care of patients (24%) and also a lower frequency of manually lifting patients (33%).

Individual characteristics, such as age, gender, work experience, and presence of back complaints and any musculoskeletal complaints, and ward characteristics were not associated with mechanical load during patient handling activities. Adjustment for the observers did not influence these results.

DISCUSSION

The actual use of ergonomic devices during patient handling activities in this study was 69%. A favourable ratio of nurses per patient was associated with a decreased duration of time spent in awkward back postures during handling anti-embolism stocking (43%), patient transfers (33%), and personal care of patients (24%) and also frequency of manually lifting patients (33%). Use of lifting devices was associated with a lower frequency of forces exerted (64%), adjustable bed and shower chairs with a shorter duration of awkward back postures (38%), and an anti-embolism stockings slide with a lower frequency of forces exerted (95%).

Table 5 Determinants of mechanical load during patient handling activities, estimated by linear mixed-effect model for repeated measurements and the explained between- and within-nurses variance by the determinants.

Category of activity	Device necessary and used, REF (CI)		Ratio fte nurse/patient, REF (CI)		Decrease of between-nurses variance, %	Decrease of within-nurses variance, %
Transfer activity with patient						
Non-neutral trunk posture	1.01	(0.8-1.4)	1.49*	(1.1-2.0)	18.3	0
Exerted forces 100-230N	3.13*	(2.0-4.8)			33.0	4.8
Exerted forces >230N	2.76*	(2.0-3.8)	1.50*	(1.1-2.0)	8.2	28.5
Personal care of patients ^a						
Non-neutral trunk posture	1.61*	(1.2-2.2)	1.31	(1.0-1.8)	0	9.6
Exerted forces 100-230N	1.00	(0.7-1.4)			3.5	0.8
Exerted forces >230N	1.01	(0.8-1.2)			4.7	0
Reposition patients within the bed (C)						
Non-neutral trunk posture	1.84	(0.9-3.6)			0.1	2.0
Exerted forces 100-230N	1.92	(0.5-3.2)			0	1.4
Exerted forces >230N	1.27	(0.6-2.5)			13.8	0
Reposition patients within the bed (D)						
Non-neutral trunk posture	0.95	(0.5-1.9)			0	0
Exerted forces 100-230N	1.70	(0.7-4.1)			17.1	0
Exerted forces >230N	1.39	(0.7-2.7)			0	0
Putting on and taking off anti-embolism stockings						
Non-neutral trunk posture	1.16	(0.7-1.9)	1.74*	(1.1-2.9)	28.5	0
Exerted forces 100-230N	21.97*	(10.9-44.3)			2.3	59.6

fte, full time equivalent; 95% CI, confidence interval; C, use of slide sheet; D, use of electric adjustable bed.

^aUse of electric adjustable bed or adjustable shower chair.

*p<0.1.

A few limitations of this study must be taken into account when interpreting the results. First of all, selection might have occurred in the participation of nursing homes since it was on voluntary basis and targeting those organisations that employed ergocoaches at their wards. These organisations will have more structured attention for prevention of high mechanical load. The actual use of ergonomic devices in this study may, therefore, be higher than in a random sample of nursing homes. However, information from national surveys in 2008 showed that 85% of the nursing homes have employed ergocoaches at the wards.³⁰ This suggests that the results of this study resemble the situation in Dutch nursing homes. Secondly, the assessment of trunk postures through observations may have resulted in some inter- and intra-observer variability, which contributes to the overall variance observed.³¹ However, due to the high number of observations, this will probably have led to a limited influence on estimates of important exposure determinants. Moreover, adjustment for the observers did not influence the estimates of exposure determinants. For the assessment of forces, a crude classification was chosen intentionally, with the advantage of less misclassification. The review of Stock et al. showed that the reproducibility of materials handling was fair to excellent with better results using a crude classification of forces instead of more



detailed classification.³² Thirdly, the definition of the required use of ergonomic devices was based on the level of functional mobility of the patients. The cognitive capabilities of the patients as well as their attitudes or preferences towards ergonomic devices could have influenced the observed actual use of ergonomic devices in this study. Attitude and preferences of patients as well as their specific needs were not determined. Fourthly, in order to evaluate the necessity of ergonomic devices, the patients were categorised into three levels of functional mobility according to national guidelines. This procedure reduced potential bias in the evaluation of the observer, whether the use of a particular device was required or not. The magnitudes of forces applied during each patient handling activity were derived from published studies with actual force measurements and expert assessments by the authors. Within the framework of this large field survey, it was considered not feasible to perform force measurements. The cut-off values of 100 and 230 N reflect the force level considered to be associated with an increased risk for musculoskeletal disorders²² and the limit value in the well-known NIOSH equation.²⁸ Fifthly, only a part of the observed nurses had repeated measurements. This might have influenced the estimates of the within-nurses variance presented in Table 4. These results should, therefore, be interpreted as indicative values. Finally, no *a priori* sampling scheme was applied to accomplish an optimal randomised distribution over all patient handling activities.³³ Therefore, it is possible that the mean exposure across different patient handling activities is biased. However, the number of samples seems sufficiently high to provide reliable information to detect differences in the average mechanical load during patient handling activities with and without the use of ergonomic devices.

During the transfer of patients, lifting devices were used in 72% of the situation it was required. The study of Evanoff et al. in the USA showed a compliance of lifting devices in long-term care facilities of approximately 38%.³⁴ The good compliance of our study cannot be easily generalised to other countries with different guidelines for use of lifting devices in healthcare. The high compliance to required use must be seen in the light of the considerable attention in the Dutch healthcare for safe patient handling with ergonomic devices and the use of strict guidance for use of specific ergonomic devices in the individual care protocols for patients, as observed in 69% of all separate patient handling activities in this study. These protocols stimulate that the way to assist a patient is no longer largely determined by the individual nurse and is tailored specifically to the patient. In these care protocols for patients, there is a strong focus on lifting aids; thus, it is not remarkable that the use of lifting devices when required during transfers was high. Adjustable shower chairs during personal care were used less often, approximately in 50% of all situations. The lack of manoeuvring space, mentioned as barrier in lifting device use, might also be a barrier in shower chair use during personal care.²⁰ An electric adjustable bed was used most of the times it was required during personal care as well as during repositioning of patients within the bed. The high compliance might be explained by the presence of electric adjustable beds in most wards. The slide sheet, on the other hand, was used in only 14% of all situations when required for repositioning

patients in bed. Organisational and individual factors might have influenced the utilization of the slide sheet, such as lack of time, not enough available, and lack of knowledge.²⁰

This study showed that the mechanical load during patient handling activities when using the required ergonomic devices was almost as low as and sometimes even lower than the mechanical load during patient handling activities without required use of ergonomic devices. The use of lifting devices during transfers reduced the forces exerted by two-thirds. These results corroborate the findings in laboratory studies and workplace surveys.^{11, 13, 16, 35, 36} Zhuang et al. found that different types of lifting devices reduced spinal loads by two-thirds.¹⁶ In a longitudinal study by Owen et al., the perceived physical exertion among nurses was reduced significantly due to lifting device use.³⁵ During personal care of patients, the use of an electric adjustable bed or a shower chair reduced the duration of awkward back postures with 36%. Caboor et al. found a significant decrease in awkward back postures during patient handling tasks when using electric adjustable beds.³⁷ The low number of observations on ergonomic devices used during repositioning patients within their beds made it not possible to properly assess the effects of a slide sheet and an electric adjustable bed separately. This might explain the increase of the duration of awkward back postures when using an electric adjustable bed for repositioning patients. The use of a compression stocking slide during putting on and taking off anti-embolism stockings reduced the forces exerted with 95%. Gelderblom et al. found that the forces exerted required for putting on and taking off anti-embolism stockings were generally between 150 and 200 N.³⁸ A biomechanical evaluation of putting on and taking off anti-embolism stockings showed that the forces exerted required for putting on and taking off anti-embolism stockings when using an compression stocking slide did not exceed 75 N.²⁶

The use of ergonomic devices explained mainly the reduction in within-nurses variance, indicating that nurses made a choice to sometimes not use the ergonomic device when it was required. Individual as well as organisational factors that vary over time may have played a role. The reduction of between-nurses variance was partly explained by the use of ergonomic devices as well. This indicated that the use of ergonomic devices differs systematically among nurses at the ward. Hence, workplace policies are required that target organisational factors that support appropriate implementation of ergonomic devices³⁹ as well as individual approaches such as training of nurses in use of ergonomic devices.⁴⁰

Furthermore, the ratio of nurses per patient at the ward appeared to have an influence on mechanical load. It has been suggested that there is a link between time pressure (an indicator for insufficient staffing resources) and musculoskeletal disorders.⁴¹ Larese and Fiorito, for example, reported that nurses in wards with a low nurse to patient ratio had more musculoskeletal disorders.⁴² Our study indicates that a favourable ratio of nurses per patients at the ward will reduce awkward back postures (overall 33%) across most patient handling activities and also will reduce sustained forces during transfer activities. This may reflect the type of organisation, the distribution of patients with respect to the functional mobility, but



also the ability to share strenuous work activities or more time to adopt appropriate work techniques.

A potential disadvantage of lifting devices use was illustrated in our study, namely the duration of transfer activities, which increased with the use of lifting devices (table 3). Garg et al. found also that lifting devices took significantly more time to make a transfer than manually lifting a patient.¹³ Time constraint was mentioned in several studies as a barrier to use lifting devices in healthcare.²⁰ Sufficient staffing might give the nurses more time to use lifting devices. However, Pellino et al. found that the total time for transfers reduced from approximately 15 min for manual transfers to approximately 10 min for transfers with a lifting device.⁴³ In our study, we were not able to demonstrate the effect of lifting devices use on the cumulative time for all involved staff spend on patient handling activities since only one nurse at a time was observed during a transfer activity and effects on activities of their colleagues in the same ward were not ascertained. Another factor that hampers a clear interpretation is that the requirement to use lifting devices during transfer activities coincides with less mobile patients, who may need more time during care procedures.

The important question remains whether the reduction in mechanical load during patient handling activities due to the prescribed use of ergonomic devices will be sufficient enough to prevent the occurrence of low back pain. It has to be considered that the occurrence of low back pain is not always work-related.⁴⁴ The aetiology of back complaints is multifactorial and epidemiological surveys have identified various individual, psychosocial, and physical risk factors.^{8, 12, 45} The occurrence of low back pain can, therefore, not entirely be prevented by the use of ergonomic devices. It has been estimated that the elimination of manual patient lifting could theoretically result in a reduction of the occurrence of low back pain by 19-54%.⁴⁵ Given the fact that the use of lifting devices in this study was associated with a considerably lower frequency of forceful exertions and duration of awkward back postures, a substantial reduction in the occurrence of low back pain may certainly be expected.

In conclusion, the actual use of ergonomic devices during patient handling activities was high in the nursing homes. The use of these devices during patient handling activities was associated with a reduction in frequency of forces exerted and duration of awkward back postures by 1.49- to 21.97-fold, and thereby, may contribute substantially to a reduction in the occurrence of low back pain.

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PART



DETERMINANTS OF ERGONOMIC DEVICES USE



Chapter



Determinants of implementation of primary preventive interventions on patient handling in healthcare: a systematic review

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ABSTRACT

Objective This systematic review aims¹ to identify barriers and facilitators during implementation of primary preventive interventions on patient handling in healthcare, and² to assess their influence on the effectiveness of these interventions.

Methods PubMed and Web of Science were searched from January 1988 to July 2007. Study inclusion criteria included evaluation of a primary preventive intervention on patient handling, quantitative assessment of the effect of the intervention on physical load or musculoskeletal disorders or sick leave, and information on barriers or facilitators in the implementation of the intervention. 19 studies were included, comprising engineering (n=10), personal (n=6) and multiple interventions (n=3). Barriers and facilitators were classified into individual and environmental categories of factors that hampered or enhanced the appropriate implementation of the intervention.

Results 16 individual and 45 environmental barriers and facilitators were identified. The most important environmental categories were "convenience and easily accessibility" (56%), "supportive management climate" (18%) and "patient-related factors" (11%). An important individual category was motivation (63%). None of the studies quantified their impact on effectiveness nor on compliance and adherence to the intervention.

Conclusion Various factors may influence the appropriate implementation of primary preventive interventions, but their impact on the effectiveness of the interventions was not evaluated. Since barriers in implementation are often acknowledged as the cause of the ineffectiveness of patient handling devices, there is a clear need to quantify the influence of these barriers on the effectiveness of primary preventive interventions in healthcare.

INTRODUCTION

Among healthcare staff the prevalence of musculoskeletal disorders (MSDs) is higher than in most other occupations.¹ Patient handling activities are a major cause of MSDs among nursing personnel.² The high occurrence of MSDs has important consequences due to substantial health care utilisation, sickness absence and permanent disability.³ A wide range of primary preventive interventions have been developed in the past to reduce physical load related to patient handling and therefore decrease the occurrence of MSDs. Conflicting results have been found for engineering interventions such as lifting devices.^{4,5} There is strong evidence that personal interventions alone, such as training on preferred patient handling techniques, are not effective.^{6,7} Either these techniques did not reduce the risk of back injury or the training did not lead to an adequate change in lifting and handling techniques.⁷ Administrative interventions, targeting work practices and policies, are often an integral part of a more comprehensive intervention. There is moderate evidence for the effectiveness of multi-dimensional interventions, which are applied more often recently.^{4,6} Nelson and Baptiste described several barriers in the implementation of patient handling devices, such as patient aversion, difficulty in use, time constraints, and insufficient numbers of available lifting devices.⁵ Dawson et al. reported poor compliance as a possible cause of the ineffectiveness of the implementation of a personal intervention in home care.⁴ The actual influence of such barriers on the effectiveness of interventions is, however, seldom taken into account.

The results of interventions will depend not only on the effectiveness of the intervention itself but also on appropriate implementation in the actual work situation.⁸ Grol and Grimshaw have emphasized the importance of the different steps which need to be taken in the implementing stage of an intervention.⁹ An important step in the implementation process is the identification of obstacles to change work practices, which may arise at the level of the individual as well as in the wider environment.⁹ Individual factors refer to variables within the person, such as motivation, attitude and a person's belief in his or her ability to use the intervention.¹⁰ Environmental factors refer to the social and physical context in which a person needs to function.¹¹⁻¹³ Although several barriers to effective implementation of patient handling devices have been identified in intervention studies, there is little insight into their impact on the effectiveness of these interventions.^{8, 14, 15}

Therefore, the aims of this systematic review are (1) to identify barriers and facilitators during the implementation of primary preventive interventions aimed at patient handling in healthcare, and (2) to assess the influence of these barriers and facilitators on the effectiveness of these interventions.



METHODS

Identification and selection of articles

PubMed and Web of Science were searched from January 1988 to July 2007 to identify relevant articles. The following keywords were used in the search strategy: (1) patient handling or patient transfer AND intervention or prevent* or ergo*; and (2) physical load or physical exposure or mechanical exposure or musculoskeletal disorder or musculoskeletal injury.

An article was included if the following inclusion criteria were met: (1) it was a study on a primary preventive intervention aimed at preventing or reducing physical load related to patient handling, as characterised by a reduction in awkward postures, strenuous movements and forceful exertions; (2) it provided quantitative information on one of the following outcome measures: physical load, musculoskeletal disorders or musculoskeletal sick leave (lost working time); (3) it provided information on barriers or facilitators in the implementation of a primary preventive intervention; and (4) it was written in English.

The selection of articles was conducted in two steps. First, all abstracts or titles found by the electronic searches were checked by two authors (EK and AB). Second, after obtaining

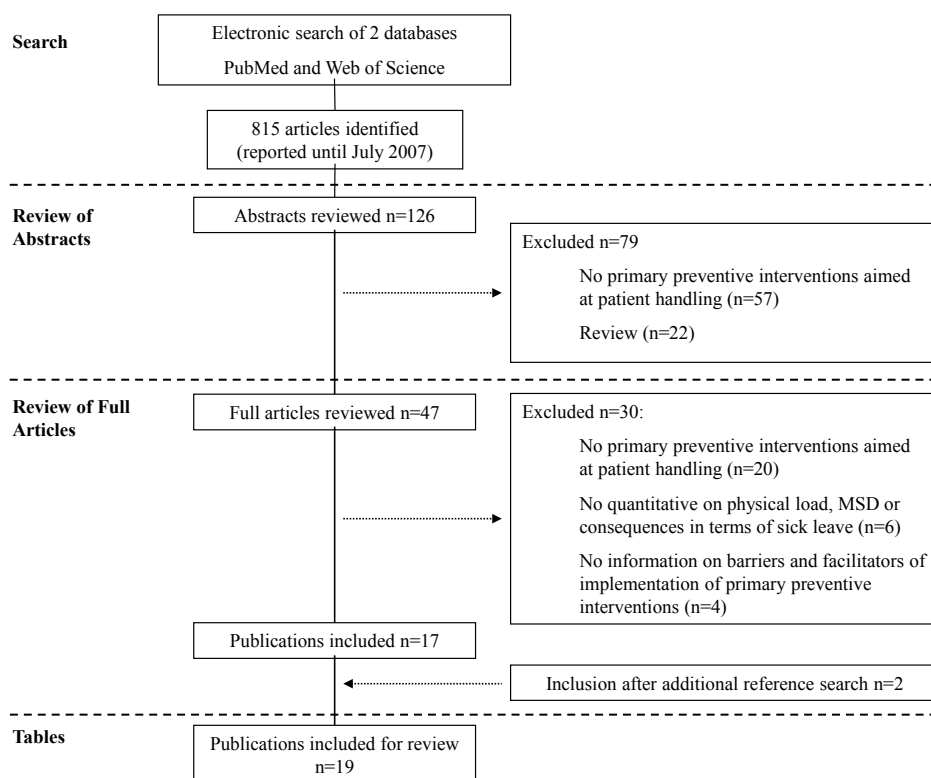


Figure 1 Overview of the literature search and review strategy.

copies of eligible articles, two authors (EK and JJK) independently assessed the articles for inclusion criteria. Disagreements were solved by consensus and if necessary, by third party (AB) adjudication. The electronic search identified 126 abstracts of potential interest and the articles 47 of these were considered for full review. Seventy nine abstracts were not eligible for further scrutiny, primarily because they failed to meet the first inclusion criterion (fig 1).

After full review, 17 of the 47 potentially relevant articles were included. The main reasons for excluding 30 articles were: no primary preventive interventions aimed at patient handling (n=20); no quantitative information on physical load, MSD or their consequences in terms of sick leave (lost working time) (n=6); and no information on barriers and facilitators in the implementation of primary preventive interventions (n=4). Some articles were excluded for several reasons.

The search was extended by screening the reference lists of the 17 articles included and this resulted in two further articles being selected. Thus, 19 articles in total were included in this systematic review.

Data extraction

Two authors (EK and JJK) performed the data extraction independently of each other according to a standardised format. Information was collected on study population, study design, study duration, outcome measures, type of primary preventive intervention, barriers and facilitators of the implementation of the intervention, and their effects with regard to the outcome measures. The studies included were categorised into four types of interventions¹⁵:

1. Engineering intervention (intervention targeting the physical work environment)
2. Personal intervention (intervention addressing personal behaviour through education and training)
3. Administrative intervention (intervention focusing primarily on organisational strategies targeting work practices and policies)
4. Multiple interventions (a combination of two or more of the above interventions)

Barriers and facilitators

Barriers were defined as factors that hampered the implementation of primary preventive interventions. Facilitators were defined as factors that enhanced the implementation of primary preventive interventions.

Two intertwined approaches were used to identify individual and environmental barriers and facilitators (table 1). The approach of Rothschild¹⁶ is oriented towards individual factors, whereas the approach of Shain and Kramer¹⁷ primarily focuses on the environmental context (table 1). Rothschild has defined three categories: motivation, ability and opportunity.¹⁶ Motivation is the willingness of individuals to undertake the necessary actions to commit to the intervention. Ability refers to the capability of individuals to do something that requires specific skills, knowledge, experience and attitude. Opportunity relates to the environ-



ment in which the intervention is implemented and was further specified by the approach of Shain and Kramer. Shain and Kramer have distinguished the categories social support, management support, supportive management climate, convenience and easy accessibility, interactivity, wide appeal, employee participation and self-efficacy.¹⁷ Employee participation and self-efficacy belong to the individual factors category and were also included in the categories of Rothschild. Social support embraces the supportiveness of family, friends, co-workers and others for the intervention. Convenience of use and easy accessibility relates to the availability of resources such as enough time to transfer patients, sufficient lifting devices, and stable staff. Management support includes the commitment of employers to the intervention. Supportive management climate refers to a work situation where the intervention is being promoted rather than hindered. Wide appeal is the attractiveness of the intervention to a broad variety of workers. Interactivity covers the reinforcement of an intervention by other work practices. In healthcare, the patient is an additional important environmental factor, encompassing the physical and cognitive capabilities of the patients, as well as the attitudes of the patients towards the intervention.¹² Within each category multiple factors can be reported as barriers or facilitators.

Data analysis

The barriers and facilitators were classified as individual or environmental factor. When possible, the qualitative and quantitative effect of the barrier or facilitator on the effectiveness of the intervention was established.

RESULTS

Table 1 describes the 45 environmental (B=27, F=18) and 16 individual (B=9, F=7) barriers (B) and facilitators (F) reported in 19 studies. The most important environmental categories were "convenience and easy accessibility" (56%), "supportive management climate" (18%) and "patient-related factors" (11%). The individual category "motivation" was mentioned most often (10 times in eight studies).

The selected studies are presented in tables 2-4 according to type of intervention. Ten studies were classified as engineering interventions,^{12, 13, 18-25} six as personal interventions,^{11, 26-30} and three as multiple interventions.³¹⁻³³ Nine of the 19 studies described both individual and environmental barriers and facilitators.^{11-13, 18, 25, 26, 28, 30, 33} Eight studies described only environmental barriers and facilitators^{19-22, 24, 29, 31, 32} and two studies^{23, 27} described only individual barriers and facilitators. Overall, 42% of the studies (n=8) described one or two barriers or facilitators, 42% of the studies (n=8) three to five barriers or facilitators, and 16% of the studies (n=3) more than five barriers or facilitators.

Table 1 Classification and summary of barriers and facilitators in the implementation of primary preventive interventions aimed at patient handling in healthcare.

Type of barrier and facilitator and source	Category	No of studies	No of barriers (B)	No of facilitators (F)
1. Individual (Rothschild et al 1999) (16)	A. Motivation: willingness of individuals to undertake the necessary actions to commit to the intervention	8	6	4
	B. Ability: capability of individuals to do something that requires specific skills, knowledge, experience, and attitude	6	3	3
2. Environment (Shain and Kramer 2004) (17)	C. Social support: supportiveness of family, friends, co-workers, and others to the intervention	3	1	2
	D. Convenience and easily accessible: availability of resources such as enough time to transfer patients, enough lifting devices, stable staff, etc	14	18	7
	E. Management support: commitment of employers to the intervention	1	-	2
	F. Supportive management climate: organisation of work in ways that promote rather than defeat the intervention	5	4	4
	G. Wide appeal: attractiveness of the intervention to a wide variety of workers	1	1	-
	H. Interactivity: reinforcement of the intervention by other work practices	1	-	1
	I. Patient-related factors	4	3	2
(Evanoff et al 2003) (12)				

Engineering interventions

Table 2 describes 10 interventions introducing lifting equipment: three studies showed a significant reduction in the occurrence of MSDs, five studies reported positive but not statistically significant effects on MSDs, one study was inconclusive, and one study had contradictory results. In total, 31 barriers and facilitators were reported, of which 74% (23 of 31) were classified as environmental factor. Overall, 52% (16 of 31) of these environmental barriers and facilitators could be categorized into the category “convenience and easy accessibility”, such as time to transfer patient with lifting device (n=5), time required to implement intervention (n=2) and availability of the lifting devices (n=2). Other environmental factors were “patient” (n=4) and “supportive management climate” (n=2). The individual category “motivation” was described in three studies and “ability” in five studies.

Personal interventions

Table 3 presents six interventions on training and education on patient handling techniques, use of engineering devices, and identification of workplace design problems. Five of the six studies showed no effect on the occurrence of MSDs. Two studies described training in the use of available transfer devices at the worksite, one of which showed a reduction in the occurrence of MSDs. In spite of the fact that transfer devices were available in the hospitals, the studies were categorised as personal intervention because the evaluation of the intervention was specifically aimed at the training programme.



Table 2 Studies with barriers and facilitators in the implementation of engineering interventions aimed at patient handling in healthcare.

Study	Design (duration)	Population (setting)	Intervention	Outcomes	Type of barrier (B) or facilitator (F)
Chhokar et al. (2005) (19)	OBS (3yrs)	All staff who handle patients (nursing home)	65 ceiling lifts and education on use	Significant reduction of MSI claims, claims costs and days lost	Time required to fully implement intervention (B-2B)
Engst et al. (2005) (20)	CT (1 yrs)	34 care staff INT, 16 care staff CON (hospital)	(1) Ceiling lifts and training session to introduce lifts; (2) no intervention	Decrease total claim costs, but increase claim costs associated with repositioning patients	Time required to alter work culture (B-2B) Ceiling lifts require more time than manually repositioning residents (B-2B)
Evanoff et al. (2003) (12)	OBS (2-3 yrs)	36 nursing units (hospital and nursing home)	25 full-body and 22 stand-up lifts and instructional course on lift operation	Significant decrease of MSI, lost workday injuries and total lost days due to injury	Think they do not need lifting devices (B-1A) Lack of knowledge (B-1B) Too time consuming (B-2B) Devices misplaced or not enough available (B-2B) Patients in isolation / connected to too many lines (B-2B) Aides or patient care techs use lifting devices (F-2B) Policy of mandatory lift usage (F-2D) Patients do not like lifting devices/ feels unstable (B-2G) Stable care activities and patient characteristics (F-2G) Lower employee-to-ergonomic device ratio (F-2B)
Fujishiro et al. (2005) (21)	OBS (2yrs)	100 work units (nursing home and hospital)	Financial support and ergonomic consultation for installing ergonomic devices	Significant decrease of MSD	
Garg and Owen (1992) (22)	OBS (1-10 mo)	57 nursing assistants in 2 units (nursing home)	Hoist, walking belt, shower chairs and training in use of devices	Reduction of back injury	Adequate staffing (F-2B) Saves time to perform transfer with 1 nursing assistant (F-2B) Reduction number of patient transfers compensated for longer transfer times associated with devices (F-2B)
Li et al. (2004) (18)	OBS (7 mo)	138 nurses in 3 nursing units (hospital)	1 portable full body sling lift, 2 stand-up sling lifts and 1 time hands-on training in lift usage	Number of injuries and lost day injuries decreased	Lack of perceived need (B-1A) Inexperience in lift use (B1B) Lack of time (B-2B) Lack of maneuvering space (B-2B) Staff turnover (B-2B)
Miller et al. (2006) (23)	CT (1yrs)	45 nurses INT and 29 nurses CON (nursing home)	(1) Portable ceiling lifts and training with regard to the ceiling lift; (2) no intervention	Decrease MSI claims and claim costs	Ceiling lifts preferred method for lifting and transferring (F-1B)

Table 2 Studies with barriers and facilitators in the implementation of engineering interventions aimed at patient handling in healthcare. (continued)

Study	Design		Intervention	Outcomes	Type of barrier (B) or facilitator (F)
	(duration)	Population (setting)			
Owen et al. (2002) (24)	CT (5yrs)	37 nurses INT and 20 nurses CON (hospital)	(1) 5 assistive devices and training in use; (2) traditionally scheduled inservice training	Decrease number of back injuries, lost work and restricted days	Patient more comfortable and secure when assistive devices used (F-2G)
Ronald et al. (2002) (13)	OBS (5 yrs)	34 RNs and 95 aides (hospital)	62 ceiling lifts and training in use	No significant reduction total MSI. Significant decline in MSI due to lifting and transferring	Preference by staff for mechanical options (F-1B) Ceiling lifts not used for repositioning due to problems with slings (B-2B) Incompatibility with pre-existing structures of older building (B-2B)
Yassi et al. (2001) (25)	RCT (1 yrs)	103 nurses INT, 116 nurses INT and 127 nurses CON (hospital)	(1) Training back care, patient assessment, and handling techniques using manual equipment; (2) Training back care, patient assessment, and handling techniques using mechanical and other assistive equipment; (3) no intervention	Number of injuries did not change significantly	Increased perception of safety among staff (F-1A) More comfortable performing patient-handling tasks (F-1B) Increasing demand by staff for mechanical equipment (F-2A) Other workplace dynamics than patient population (B-2D) Changing patient population (B-2G)

CON, control group; CT, Controlled Trial; INT, intervention group; MSD, Musculoskeletal Disorders; MSI, Musculoskeletal Injuries; OBS, observational study; RCT, Randomised Controlled Trial. Type of barrier: B-2B represents a barrier (B), within environment (2), category B (convenience and easy accessibility).



Table 3 Studies with barriers and facilitators in the implementation of personal interventions aimed at patient handling in healthcare.

Study	Design (duration)	Population (setting)	Intervention	Outcomes	Type of barrier (B) or facilitator (F)
Best (1997) (11)	RCT (1 yrs)	18 staff INT and 37 staff CON (nursing home)	(1) 32 hour training in techniques to decrease lifting using semi-squat posture and weight transfer techniques such as bracing, pivoting, lunging and counterbalancing the load; (2,3) in-house orientation training;	No significant difference in back pain after 12 months	Influenced attitude of staff by delay of opening nursing homes (B-1B) Nurses wanting to transfer the patient 'the old way' (B-2A) Variety of skill and knowledge levels due to unstable staff (B-2B)
Feldstein et al. (1993) (26)	CT (1 mo)	50 subjects INT and 25 subjects CON (hospital)	(1) 2 hour didactic session in proper body mechanics, patient transfer techniques, one-on-one assistance, reinforcement of proper use of equipment, and problem identification on environmental hazards, and 8-hour of practical time on units over 2 weeks; (2) no intervention	No significant change in back pain and back fatigue.	Nurses put patients first (B-1A) Nurses concerned over loss of continuity of care to patients during program participation (B-1A) Low moral after nursing strike ending shortly before study began (B-1A) Items taught in the course are almost a curse to the work culture of the nurses (B-2E) Patient handling methods seen as good methods (F-1A)
Johnsson et al. (2002) (27)	OBS (6 mo)	51 nursing assistants (hospital and primary care)	Training in patient handling methods and moving skills, physical and psychosocial risk factors, balance between patient's need for rehabilitation and use of lifting aids and workplace design, and awareness of body movements; 2 models of learning	No decrease in musculoskeletal problems	
Lagerström et al. (1998) (28)	OBS (3 yrs)	348 participants (hospital)	Education and training program in patient transfer technique and how and when to use lifting devices; physical fitness exercise and stress management	No significant reduction of musculoskeletal symptoms	Working technique was appreciated by nurses (F-1A) Need for common work technique emphasized by different actors, like the Occupational Healthcare Department, the labour unions, and the nursing personnel (F-2A) All nursing personnel educated and trained at the same time (F-2B) Management's detailed knowledge of the personnel's working conditions and needs (F-2C) Need for common work technique according to management (F-2C) Management applied for money to carry out the program (F-2D) Hospital already well-equipped with transfer devices (F-2D) Permanent component of competence training for nursing staff by continuous follow-up (F-2F)

Table 3 Studies with barriers and facilitators in the implementation of personal interventions aimed at patient handling in healthcare. (continued)

Study	Design (duration)	Population (setting)	Intervention	Outcomes	Type of barrier (B) or facilitator (F)
Lynch and Freund (2000) (29)	CT (30-60 d)	Pretest 164 nurses, posttest 59 trained nurses and 45 controls (hospital)	(1) Back injury training program in back injury risk factors, risky activities, control strategies including engineering controls, administrative controls, use proper body mechanics when handling patient; (2) staff not attending to training	Reduction of number of reported lost-time back injuries from 7 in the first 3 quarters of 1996 to 1 in the 4 th quarter of 1996	Lack of availability of mechanical devices (B-2B)
Peterson et al. (2004) (30)	CT (1 mo)	2 units INT and 1 unit CON (nursing home)	Training in correct ergonomic work practices, administrative strategies, and use of engineering controls (1) only NAs trained, reinforced by RA; (2) all nurses trained, training reinforced by daily supervision from the registered nurses and licensed practical nurses; (3) no training	No significant difference in pain/discomfort survey.	NA not wanting to participate because of other priorities (B-1A) Lack of time to reinforce training on the floor (B-2B) NA not wanting to participate because of high turnover rate (B-2D)

CON, control group; CT, Controlled Trial; INT, intervention group; NA=nursing assistant; OBS, observational study; RA, research assistant; RCT, Randomised Controlled Trial. Type of barrier: B-1B represents a barrier (B), within individual (1), category B (ability).



Table 4 Studies with barriers and facilitators in the implementation of multiple interventions aimed at patient handling in healthcare.

Study	Design (duration)	Population (setting)	Intervention	Outcomes	type of barrier (B) or facilitator (F)
Charney et al. (2006) (31)	OBS (1 to 4 yrs, average 2 yrs)	31 hospitals (hospital)	Zero-lift program: (1) replace manual lifting with mechanical lifting, (2) written policy and procedures supporting mechanization of lifting, (3) training, (4) zero lift committee and (5) patient screening procedure to determine ambulatory level of new patients	Significant reduction in time lost injuries and frequency of injuries	Initial investment not easily allocated in some hospitals (B-2B) Initiated with less equipment and later augmented when funds were available (B-2B) High turnover rates (B-2B) Mandatory use of equipment (F-2D) No standardised assessment of patient ambulatory status (B-2D) Each hospital put his individual stamp on the zero lift model (B-2D)
Kribbe and Friele (1999) (32)	CT (1 yrs)	139 subjects INT and 239 subjects CON (home care)	(1) Patient hoists (40); (2) training, (3) introduction of 12 specially trained lifting coordinators, (4) no intervention	Significant reduction back pain prevalence. Significant reduction of total number of transfers	Relatives able to care for patients with use of hoist without presence of nurse (F-2B)
Nelson et al. (2006) (33)	OBS (9 mo)	23 high risk units in 7 facilities (home care and hospital)	6 program elements: (1) Ergonomic Assessment Protocol, (2) Patient Handling Assessment Criteria and Decision Algorithms, (3) Peer Leader role, "Back Injury Resource Nurses", (4) State-of-the-art Equipment, (5) After Action Reviews, and (6) No Lift Policy.	Significant reduction of injury rates significantly and modified duty days.	Patient handling equipment well accepted by staff (F-1A) No viable technology solutions for high-risk, high-volume patient handling task: repositioning patient in bed or chair (B-2B) Patients less likely to embrace new patient handling technologies and practices at the onset of the program (B-2G)

CON, control group; CT, Controlled Trial; INT, intervention group; OBS, observational study; RCT, Randomised Controlled Trial. Type of barrier: B-2B represents a barrier (B), within environment (2), category B (convenience and easy accessibility).

In total, 20 barriers and facilitators were described, of which 65% (13 of 20) were classified as environmental factors, most notably the category “convenience and easy accessibility” (n=4). In addition, 86% (6 of 7) of the individual barriers and facilitators were categorised into “motivation”, often referring to attitudes towards intervention (n=2) and working techniques seen as good methods (n=2). All the other individual and environmental categories were mentioned at least once as a barrier or facilitator, except for patient-related factors.

Multiple interventions

Table 4 describes three multidimensional interventions which resulted in a significant reduction in MSDs. All three interventions involved lifting devices and peer leader roles or committees as part of the multidimensional intervention. In total, 10 barriers and facilitators were described, of which 90% (nine of 10) were classified as environmental factors. Overall, 65% (five of nine) of the environmental barriers and facilitators were in the category “convenience and easy accessibility”, such as high turnover rates and initial investment not easily allocated. Other environmental categories were “supportive management climate” (n=3) and “patient” (n=1). The individual category “motivation” was described in one study where patient handling equipment was well accepted by staff.

Influence of barriers and facilitators on effectiveness

None of the studies presented a quantitative evaluation of the influence of the barriers and facilitators during implementation on the effectiveness of the interventions. One study included the assessment of barriers for usage of lifting devices in the study design by interviewing nurses during the intervention period.¹² The influence of these barriers on the effectiveness of the intervention was, however, not evaluated. In five studies barriers and facilitators were assigned retrospectively by the researcher as possible factors having influenced the effectiveness of the intervention.^{12, 13, 19, 21, 31, 33}

DISCUSSION

This review showed that various individual and environmental factors were of importance when implementing primary preventive interventions in the actual work situation. A key issue in the implementation of primary preventive interventions appeared to be the environmental category “convenience and easy accessibility”, for example, time required to transfer patients, staff situation, and availability of lifting devices. Barriers and facilitators in the studies were identified retrospectively and their importance was described in qualitative terms. None of the studies carried out a quantitative evaluation of the influence of relevant barriers and facilitators during the implementation on the effectiveness of the primary preventive intervention.



This review has some limitations. First, the literature search may not have been complete since the review was restricted to studies published in English and available in two different electronic databases. The second electronic database provided nine (19%) unique titles being considered for full review and resulted in three out of 19 studies included. Due to possible incompleteness of reports, the importance of the current study lies in the identification of various factors that may hamper or facilitate the effectiveness of a primary preventive intervention, rather than in the presentation of the exact distribution of individual and environmental factors that affect the effectiveness of patient handling interventions. Second, an essential inclusion criterion of this review was that a study should describe the effects of a primary preventive intervention on reduction in physical load, MSDs or musculoskeletal sick leave and report on relevant barriers and facilitators during the implementation of the intervention. This was decided because we wanted to assess which factors influence the implementation of primary interventions in healthcare and what the actual influence of these barriers and facilitators was on the effectiveness of the primary interventions. Thus, qualitative publications primarily focusing on barriers and facilitators in appropriate implementation of interventions without addressing the intervention effects itself were not selected for this systematic review. Such publications may shed more light on the planning and processing of the implementation of interventions.⁸ It is expected, however, that the barriers and facilitators identified in this review will also be addressed to some extent in qualitative studies. Furthermore, this review was constricted to studies on primary preventive interventions aimed at patient handling in healthcare. Other interventions in healthcare organisations may involve other barriers and facilitators. Third, this systematic review refrained from assessing the methodological quality of the articles selected. This review does not address effectiveness of interventions or exposure-response relationships for which quality of the study may be a critical issue. It could be hypothesised that better quality of the implementation process will result in a higher effectiveness, but so far we lack the instruments to evaluate this. Finally, the chosen approaches of Rothschild¹⁶ and Shain and Kramer¹⁷ may have influenced the classification of the barriers and facilitators. For example, most barriers and facilitators were reported within the category “convenience and easy accessibility” (25 out of 61), which suggests a more detailed classification is needed. Nevertheless, the analysis presented shows the importance of both environmental as well as individual factors in the (successful) introduction of primary preventive interventions at the workplace and, thus, these factors need to be taken into account in studies evaluating the effectiveness of primary preventive interventions.

Overview of barriers and facilitators

The majority of the selected studies in this review identified several factors that could have interfered with the effective implementation of primary preventive interventions on patient handling in healthcare. Environmental factors seemed to be more important than individual

factors, independent of the type of intervention. For the engineering interventions, almost 80% of the reported barriers and facilitators were categorised into environmental factors and for the multiple interventions this was about 90%. Rather surprisingly, in evaluation studies on personal interventions through education and training, environmental factors (65%) were more often reported than individual factors (35%). Thus, it appears that the social and physical context in which the primary preventive intervention is implemented is of paramount importance.

Influence of barriers and facilitators on effectiveness

Only articles with quantitative data on physical load, MSD, or their consequences in terms of sick leave were included in this review, anticipating that a quantitative analysis of the influence of barriers and facilitators on the effectiveness of primary preventive interventions at the workplace would be possible. However, it is remarkable that, considering the reported importance of these factors in the evaluation studies, only one study explicitly included the assessment of barriers in lift usage in the design of the study and that none of the studies quantitatively evaluated the influence of these factors on the effectiveness of the primary intervention.¹² Therefore, a quantitative analysis of the relative importance of personal and environmental factors in the effectiveness of interventions was unfortunately not possible in this review.

In five studies the barriers and facilitators were assigned retrospectively by the researcher as having possibly influenced the effectiveness of the primary intervention. Chhokar et al. mentioned that the time required to alter work culture and to fully implement changes in patient handling practices may have prolonged the latency period between introducing the ceiling lifts and the observed change in compensation claims.¹⁹ Evanoff et al. reported that the larger reduction in injuries observed in some facilities were likely due to a policy of mandatory lift usage and established care activities and patient characteristics.¹² It is, however, difficult to determine the actual influence of these barriers and facilitators on the effectiveness of the primary intervention when researchers and stakeholders involved only provide a qualitative assessment. Fourteen studies identified barriers and facilitators in the implementation process of the primary intervention but did not report on their potential impact on the effectiveness of the intervention. The drawback of this approach is that the effectiveness of a primary intervention is separated from the implementation process. Theories on implementation in healthcare emphasise the importance of identifying obstacles to changing work practices and argue that their influence on the implementation process and the effectiveness of an intervention need to be assessed.³⁴ There is still little guidance regarding the quantification of barriers and facilitators, but a necessary first step will be to rate the quality of the implementation.³⁵ A second step will be more detailed assessment of individual and environmental factors, for example, the number of lifting aids available



relative to the number of patients, the proportion of patient protocols with requirements on lifting procedures, and the percentage of nurses trained in the use of lifting aids.

The adoption and implementation of primary preventive interventions in healthcare require comprehensive approaches at different levels.⁹ Barriers that hamper the appropriate implementation of primary preventive interventions are complex, multifunctional and influenced at many levels of the healthcare system, including the individual, patient, social, organisational, economical, and political.³⁶ This requires the adaptation of implementation models, as in the approaches of Rothschild and Shain and Kramer.^{16, 17} In evaluation studies on the effectiveness of these primary interventions, it remains a challenge to incorporate important barriers and facilitators into the study design so as to enable a quantitative evaluation of their influence on the effectiveness of the interventions.

In conclusion, various individual as well as environmental factors may influence the appropriate implementation of primary preventive interventions and, thus, the effectiveness of these interventions. Environmental factors were far more often reported than individual factors, independent of the type of intervention. The identified barriers and facilitators were only described in qualitative terms and were usually not included in the design of the study but collected afterwards. None of the studies presented a quantitative evaluation of the influence of relevant barriers and facilitators on the effectiveness of the primary intervention. Since many barriers and facilitators have been acknowledged as causing failure of the effective implementation of primary interventions on patient handling, there is a clear need to quantify the impact of these barriers and facilitators on the effectiveness of primary preventive interventions.

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Chapter



Individual and organisational determinants of use of ergonomic devices in healthcare

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ABSTRACT

Objective This study aims to identify individual and organisational determinants associated with the use of ergonomic devices during patient handling activities.

Methods This cross-sectional study was carried out in 19 nursing homes and 19 hospitals. The use of ergonomic devices was assessed through real-time observations in the workplace. Individual barriers to ergonomic device use were identified by structured interviews with nurses and organisational barriers were identified using questionnaires completed by supervisors and managers. Multivariate logistic analysis with generalised estimating equations for repeated measurement was used to estimate determinants of ergonomic device use.

Results 247 nurses performed 670 patient handling activities that required use of an ergonomic device. Ergonomic devices were used 68% of the times they were deemed necessary in nursing homes and 59% in hospitals. Determinants of lifting device use were nurses' motivation (OR 1.96), the presence of back complaints in the past 12 months (OR 1.77) and the inclusion in care protocols of strict guidance on the required use of ergonomic devices (OR 2.49). The organisational factors convenience and easily accessible, management support and supportive management climate were associated with these determinants. No associations were found with other ergonomic devices.

Conclusions The use of lifting devices was higher in nursing homes than in hospitals. Individual and organisational factors seem to play a substantial role in successful implementation of lifting devices in healthcare.

INTRODUCTION

Low back pain is the most common musculoskeletal disorder among nurses.¹⁻⁶ A significant proportion of back pain episodes can be attributed to events that occur during patient handling activities. Nurses are exposed to lifting, awkward working postures, and pushing or pulling during patient handling activities. These activities have been reported as an important cause of back complaints.^{5, 7-9}

In the past number of years many ergonomic interventions have been developed to reduce exposure to physical load related to patient handling activities in order to (partly) reduce the occurrence of back complaints. The efficacy of ergonomic devices designed to reduce exposure to physical load has been assessed in a number of laboratory studies.¹⁰⁻¹³ However, the implementation of these ergonomic devices in the actual work situation remains difficult, and workplace studies have difficulties showing the effectiveness of ergonomic devices as regards the occurrence of back complaints.¹⁴ An important step in the implementation process is the identification of obstacles to changing work practices, which may arise at the level of individuals as well as the wider environment.¹⁵ In the review of Koppelaar et al., five studies identified individual factors, such as lack of perceived need and lack of knowledge, and nine studies identified organisational factors, such as lack of time, lack of a policy of mandatory lift usage, and employee-to-ergonomic device ratio, which may hamper the effective implementation of ergonomic devices in the workplace.¹⁶ Although many barriers have been identified in intervention studies, none of the intervention studies assessed the influence of these barriers on the actual use of the ergonomic devices.¹⁶

Therefore, the aim of this study was to evaluate the influence of individual and organisational determinants on the actual use of ergonomic devices during patient handling activities in healthcare.

METHOD

Study population

This cross-sectional study took place in 19 nursing homes and 19 hospitals in the Netherlands. Organisations with a structured patient handling programme including the presence of ergocoaches were included. An ergocoach (also called a peer leader, lifting coordinator, back injury resource nurse, lifting specialist and mobility coach) is a person trained and specialised in ergonomic principles who works in a ward like any other nurse. An ergocoach is responsible for starting and maintaining the process of working according to ergonomic principles by being available for questions from colleagues, identifying problems with and conducting assessments of physical load, contributing to workplace improvements, and training of personnel.¹⁷ Nursing homes and hospitals were contacted and 46% and 45%, respectively,



agreed to participate. Primary reasons for non-participation were lack of time, merger of the facility, and construction work in the facility. Participating and non-participating facilities did not differ as regards location (city versus village); however, no additional information was collected about non-participating facilities. Informed consent was obtained verbally from all nursing homes and hospitals prior to the study.

In the Netherlands, there are two types of nursing homes. First, there are those for long term care of the elderly who are not able to live independently (n=10). These provide general support and uncomplicated nursing care for those with physical, psychogeriatric or psychosocial problems as a result of old age. The other type of home looks after those who need specific nursing care, residential care or revalidation as a result of disease, disorder or old age but no longer need specialised medical care in a hospital (n=9). This study also took place in general hospitals in wards with a patient population staying at least a couple of days.

The data collection was carried out between 2007 and 2009 among nurses as well as organisations. Individual nurses (professional nurses and nursing assistants) were observed while performing patient handling activities and interviewed afterwards to gather additional information on individual characteristics and barriers to the use of ergonomic devices during patient handling activities. At the organisational level, information on ward characteristics and ward policies were collected by means of a self-administered questionnaire completed by the team leader on the ward and the ergocoach. Managers of the nursing homes and hospitals were asked about organisational policies in self-administered questionnaires.

Use of ergonomic devices

Observations in the workplace were carried out to collect information about the type of ergonomic devices used during the different patient handling activities. Real-time observations were conducted to assess patient handling activities in relation to the demands of national practice guidelines developed by the healthcare sector.^{17, 18} A checklist was used to collect information about the types of ergonomic devices and the necessity for ergonomic devices. The different ergonomic devices assessed during patient handling activities were lifting devices for transferring a patient, an electrically operated adjustable bed and adjustable shower chair for use during personal care, an electrically operated adjustable bed and slide sheet for repositioning a patient in bed, and a compression stocking slide for putting on and taking off anti-embolism stockings.¹⁷ For personal care of patients, the use of an adjustable bed and use of an adjustable shower chair were assessed separately because these ergonomic devices were used in different personal care situations. An adjustable bed is used during personal care in bed, such as washing and dressing a patient, and an adjustable shower chair is used for showering a patient in a sitting or semi-sitting position. For repositioning patients in bed, the use of an adjustable bed and the use of a slide sheet were assessed separately since the criteria for use of these ergonomic devices differ. An adjustable bed is used to reduce awkward trunk postures, but can also eliminate the need for a transfer and/or reduce the

power required for a transfer, while a slide sheet is a friction-reducing device aimed to reduce the manual forces required.¹⁸

The requirement for and actual use of the ergonomic devices were assessed according to national practical guidelines that have been developed by the healthcare sector.^{17, 18} The criteria for use of specific ergonomic devices during patient handling activities are based on the functional mobility of the patients. Three levels can be distinguished: (1) patients who are able to perform activities by themselves; (2) patients who are able to assist and contribute actively, but unable to perform the activity on their own; and (3) patients who are passive with none or very little contribution to the required movements.¹⁹ For transferring a patient, a lifting device is compulsory for a patient in the second and third categories. Adjustable beds were present in most wards and actual use by the nurse was defined when the height of the adjustable bed was appropriate for the patient handling activity being performed. Adjustable shower chairs are required when a patient in the second or third category is showered in a sitting position. For repositioning patients within the bed, an adjustable bed and slide sheet are compulsory for patients in the second and third categories. A compression stocking slide should always be used for putting on and taking off patient anti-embolism stockings, independent of the functional mobility of the patient.¹⁸ For each patient a specific protocol is available stating when an ergonomic device should be used, whereby the patient's functional mobility is linked to the national practice guidelines for use of ergonomic devices in specific situations. In the absence of this information, nurses were asked to provide information about the functional mobility to assess the requirement for an ergonomic device relative to the patient's characteristics. During the observations the researcher first collected information on the required use of ergonomic devices and subsequently determined during patient handling activities whether these ergonomic devices were actually used. At the start of the observations nurses were asked to participate in the study. The nurses were observed in real-time during a specific patient handling activity. In total, 670 patient handling activities were observed with a total duration of approximately 54 h.

Determinants of ergonomic devices use

Information on potential determinants of ergonomic devices use during patient handling activities was obtained at three levels: organisations, wards, and individual nurses. For each organisation information was gathered about the number of wards, number of workers and number of patients. For each ward within the organisation, information was obtained about the number of patients, number of nurses and number of ergocoaches. The ratios of (full-time equivalent) nurses per ergocoaches and the ratio of (full-time equivalent) nurses per patient were calculated per ward and median values were used as the cut-off. Nurses were interviewed concerning age, back complaints and any musculoskeletal complaints, defined as 'the presence of pain or discomfort in the past 12 months'²⁰, and planned behaviour with regard to ergonomic devices use.



Two intertwined approaches were used to identify individual and organisational determinants of ergonomic devices use (table 1) as described in the review of Koppelaar et al.¹⁶ The first approach of Rothschild is oriented towards individual factors, whereas the second approach of Shain and Kramer primarily focuses on the organisational context.^{21,22} The definition of the different categories and the measurement methods are described in table 1. The individual factor motivation to use lifting devices or other ergonomic devices was measured according to a planned behaviour model following the six consecutive stages of planned behaviour.²³ These stages of planned behaviour were categorised into three groups: attention through intention, changed behaviour and maintenance of behaviour.

Data analysis

The influence of individual and organisational determinants (table 1) on the outcome variable actual use of ergonomic devices was analysed using multivariate logistic regression analysis with generalised estimating equations (GEE), suitable for the analysis of repeated measurements. The analyses were performed for each patient handling activity separately: (1) lifting device use during transfer of a patient; (2) adjustable bed or adjustable shower chair use during personal care of patients; (3) slide sheet or adjustable bed use during repositioning of patients in bed; and (4) compression stocking slide use during putting on and taking off anti-embolism stockings. The OR was used as measure of association, and indicates the influence of a determinant on ergonomic device use during patient handling activities. An OR > 1 reflects that the determinant is associated with increased use of an ergonomic device.

The following procedure was used to identify determinants of actual use of ergonomic devices during the patient handling activities. First, all individual as well as organisational variables were analysed in univariate logistic GEE models. The categories with a p-value less than 0.20 were selected for further investigation. Second, for those variables that consisted of a composite score across different items, the single items were also analysed in univariate logistic GEE models and identified for further investigation when the p value was less than 0.20. third, a multivariate logistic GEE model with individual and organisational variables as independent variables was constructed by forward selection. Variables with a p-value less than 0.10 were retained in the final model.

The association of upstream factors with the individual factor motivation of nurses to use lifting devices as well as the availability of patient specific protocols with strict guidelines for ergonomic device use were analysed with Spearman correlations.

Statistical analyses were performed using Proc Genmod in SAS v 9.2.

Table 1 Definitions and methods of measurements of individual and organisational determinants according to the models of Rothschild and Shain and Kramer.

Type	Definition	Source	Determinants
1. Individual determinants (Rothschild et al. 1999) [21]	Motivation: willingness of a nurse to undertake the necessary actions to commit to the intervention	N	1. Attention: do you know the existence of the workplace guidelines for physical load?
		N	2. Understanding: do you know when and which ergonomic device you have to use when lifting or transferring patients?
		N	3. Attitude: do you think it is always necessary to use ergonomic devices when lifting or transferring patients with limited mobility or passive patients?
		N	4. Intention: do you always intend to use ergonomic devices when lifting or transferring patients with limited mobility or passive patients?
		N	5. Changed behaviour: do you always use ergonomic devices when lifting or transferring patients with limited mobility or passive patients?
		N	6. Maintenance of behaviour: does it happen, once in a while, that you do not use ergonomic devices when lifting or transferring patients with limited mobility or passive patients?
2. Organisational determinants (Shain and Kramer) [22]	Ability: capability of a nurse to do something that requires specific skills, knowledge and experience	N	Years of work experience
		N	Knowledge of national guidelines
	Convenience and easily accessible: availability of resources such as to use ergonomic	R	Storage location of ergonomic devices (in the room of the patient or elsewhere)
		R	Location of bathroom (attached to the room of the patient or not)
		R	Ratio of number of ergonomic devices per patient on the ward.
	Management support: commitment of employers to the ergonomic devices	M	Amount of money spent on maintenance of ergonomic devices (at least €7000 annually was seen as favourable)
		M	Policy of reserving money for activities or supplies to reduce physical load
	Supportive management climate: a work organisation which actively promotes use of ergonomic devices	M	Annual training of nurses in the use of ergonomic devices
		T	Policy of regular checking amount of ergonomic devices in proportion to mobility of patients
		T	Existence of a policy on the maintenance of ergonomic devices on the ward
Interactivity: reinforcement of ergonomic devices by other work practices		T	Physical load a regular topic in team meetings or not
		E	Amount of time that ergocoaches spent on their ergocoach activities per week (mean number of hours per week)
		R	Availability of patient specific protocols with strict guidelines for ergonomic device use
		R	Availability of patient specific protocols with strict guidelines for ergonomic device use

E: self-administered questionnaire of ergocoach; M: self-administered questionnaire of manager; N: structured interview of nurses; R: checklist filled out by researcher; T: self-administered questionnaire of team leader.



RESULTS

Of the 162 team leaders from nursing homes and hospitals invited to participate in the study, 144 returned the self-administered questionnaire (response 89%). Of the 269 ergocoaches invited to participate, 233 returned the self-administered questionnaire (response 87%). All managers (n=38) invited to participate returned the self-administered questionnaire (response 100%). In total, 343 nurses participated in this study and for 247 nurses data collection on observations of patient handling activities and interviews was complete. Nurses participated anonymously in this study. None of the nurses who were invited to contribute to the study refused to participate. A total of 96 nurses were not included because they performed patient handling activities without needing an ergonomic device or were not interviewed due to lack of time. The 247 nurses performed 670 patient handling activities that required the use of an ergonomic device.

The study population consisted predominantly of women, ranging in age from 16 to 62 years (table 2). The average working experience of the nurses was slightly higher in nursing homes than in hospitals. The 12-month prevalence of back complaints and of any musculoskeletal disorders was 43-45% and 58-65%, respectively. Nursing homes and hospitals differed considerable with respect to number of wards, number of workers and number of patients per ward and per organisation. The ratio of patients per full-time equivalent nurses per ward ranged from 0.3 to 7.8 for nursing homes and from 0.2 to 2.3 for hospitals.

Table 2 Organisational and ward characteristics of nursing homes and hospitals, and individual characteristics of nurses in these organisations.

Characteristics	Nursing homes	Hospitals
Organisational		
Number of wards per organisation, median (range)	4 (1-12)	29 (5-111)
Workers (fte) per organisation, median (range)	118 (26-400)	1600 (393-3000)
Patients per organisation, median (range)	126 (68-320)	453 (150-1070)
Ward	(n=66)	(n=96)
Patients per ward, median (range)	30 (12-74)	19 (8-41)
Nurses (fte) per ward, median (range)	14 (4-62)	22 (11-64)
Ratio patient/fte nurses per ward, median (range)	1.7 (0.3-7.8)	1.0 (0.2-2.3)
Ratio fte nurses per peer leader, median (range)	9.7 (2.7-30.0)	13.7 (5.5-64.0)
Individual	(n=132)	(n=211)
Age, years, mean (SD)	36 (16-62)	29 (17-58)
Gender, female %	92	91
Working experience (years), median (range)	7 (0-43)	6 (0-40)
Back complaints in the past 12 months, %	43%	45%
Musculoskeletal complaints in the past 12 months, %	58%	65%

fte=full time equivalent.

Table 3 Occurrence of individual and organisational barriers to ergonomic device use during patient handling activities in nursing homes and hospitals.

Type	Scale	Source	Determinants	Nursing homes	Hospitals
Individual	Motivation	N	Stage of planned behaviour to use lifting devices:	Attention through intention	8%
				Changed behaviour	36%
Organisational	Ability	N	Stage of planned behaviour to use other ergonomic devices:	Maintenance of behaviour	29%
				Attention through intention	63%
				Change behaviour	17%
				Maintenance of behaviour	45%
	Convenience and easily accessible	R	Low work experience		31%
					29%
					24%
					51%
	Management support	M	Lack of knowledge of workplace guidelines		48%
					2%
					7%
					44%
					67%
					40%
					21%
					89%
Supportive management climate	T	Unfavourable ratio of lifting devices per patients		13%	
				38%	
				35%	
				53%	
Interactivity	E	Unfavourable ratio of slide sheets per patients		10%	
				40%	
				51%	
				20%	
	R	Unfavourable ratio of adjustable shower chairs per patients		5%	
				22%	
				18%	
				65%	
	R	Lifting devices not close to facility of bed		27%	
				59%	
				68%	
				96%	
	R	Other ergonomic devices not close to facility of bed		35%	

E: self-administered questionnaire of ergocoach; M: self-administered questionnaire of manager; N: structured interview of nurses; R: checklist filled out by researcher; T: self-administered questionnaire of team leader.



Table 3 describes the prevalence of individual and organisational determinants of ergonomic device use during patient handling activities by healthcare branch. The prevalence of barriers was generally higher in hospitals than in nursing homes. A low amount of time spent on ergocoach activities, an unfavourable ratio of slide sheets per patient, and lifting devices not close to bed were more prevalent in nursing homes (59%, 62% and 89%, respectively). In hospitals an unfavourable ratio of adjustable shower chairs per patient, lifting devices not close to facility of bed, and absence of patient specific protocols with strict guidelines for ergonomic device use were more prevalent (70%, 93% and 96%, respectively).

Table 4 provides descriptive information on 670 observed patient handling activities observed which required the use of an ergonomic device, performed by 247 nurses. The actual use of ergonomic devices when required during patient handling activities ranged from 0% for adjustable shower chairs in hospitals to 92% for adjustable beds in hospitals. The use of ergonomic devices was similar between nursing homes and hospitals, except for a higher use of lifting devices during the transfer of a patient and of adjustable shower chairs during personal care of patients in nursing homes.

Table 4 Characteristics of the observed patient handling activities with requirement of an ergonomic device and the actual ergonomic devices use in nursing homes and hospitals.

	Nursing homes (n=19)			Hospitals (n=19)			Devices
	N	n	Device used	N	n	Device used	
Transfer	101	145	105 (72%)	71	80	34 (43%)	Lifting devices
Personal care of patients (A)	62	81	73 (90%)	82	86	79 (92%)	Electric adjustable bed
Personal care of patients (B)	26	28	15 (54%)	3	3	0 (0%)	Adjustable shower chair
Repositioning patients within the bed (A)	68	88	13 (15%)	107	119	14 (12%)	Slide sheet
Repositioning patients within the bed (B)	68	88	75 (85%)	107	119	101 (85%)	Electric adjustable bed
Put on and pull out compression stockings	20	28	16 (57%)	12	12	5 (42%)	Compression stocking slide
Total	110	370	253 (68%)	137	300	176 (59%)	

N, number of nurses; n, number of observations with necessity of an ergonomic device according to workplace guidelines.

Table 5 shows that the individual factors being motivated to use lifting devices and having had back complaints in the past 12 months were important factors for increased lifting device use during patient transfer with ORs of 1.96 and 1.77, respectively. The availability of patient specific protocols with strict guidelines for ergonomic device use had an OR of 2.49. No associations were found between individual and organisational determinants and the use of an adjustable bed or an adjustable shower chair during personal care of patients, the use of a sliding sheet or an adjustable bed during repositioning of patients in bed, or the use of a compression stocking slide when putting on and taking off anti-embolism stockings.

Table 5 Associations between individual and organisational factors and the use of lifting devices during the transfer of a patient in nursing homes and hospitals.

	Lifting device use during patient transfer			
	Univariate		Multivariate (N=238)	
	OR	95% CI	OR	95% CI
Individual factors				
Motivation: changed or maintenance of behaviour to use lifting devices	2.37**	1.20-4.67	1.96**	1.00-3.86
Ability	0.64	0.36-1.13		
Work experience	0.63	0.36-1.12	-	
Knowledge of national guidelines	0.64	0.12-3.36	-	
Back complaints in the past 12 months	1.52	0.85-2.72	1.77*	0.99-3.22
Any musculoskeletal complaints in the past 12 months	1.20	0.67-2.14	-	
Organisational factors				
Convenience and easily accessible	0.82	0.39-1.71	-	
Management support	1.34	0.71-2.53		
Supportive management climate	2.03*	0.87-4.74		
Regular checking of amount of ergonomic devices in proportion to mobility of patients	1.57	0.70-3.51	-	
Policy on maintenance of ergonomic devices	1.30	0.57-2.96	-	
Physical load regular topic in team meetings	1.48	0.80-2.73	-	
Interactivity	2.13 **	1.20-3.76		
Amount of time spending on peer leader activities per week	1.45	0.78-2.70	-	
Availability of patient specific protocols with strict guidelines for ergonomic device use	2.67 **	1.40-5.09	2.49**	1.27-4.89

*p<0.10.

**p<0.05.

N=number of nurses.

DISCUSSION

This study shows that ergonomic devices were actually used 68% of times they were required in nursing homes and 59% in hospitals. Lifting device use during transfer of a patient was strongly associated with motivation among nurses to use lifting devices and experienced back complaints in the past 12 months, as well as the availability of patient specific protocols with strict guidelines for ergonomic device use.

There are a few limitations that must be taken into account in this study. First of all, the cross-sectional design did not permit determination of the direction of association between the studied factors and device use. Second, selection might have occurred since participation of nursing homes and hospitals was on a voluntary basis and targeted those that employed ergocoaches on wards. These organisations may have been focussed on preventing high physical load. The actual use of ergonomic devices in this study may, therefore, be higher than in a random sample of nursing homes and hospitals. However, information from national surveys in 2008 showed that 85% of nursing homes have employed ergocoaches on wards.²⁶ Information from national surveys among hospitals in 2005 showed that ergocoaches were



present in 56% of the hospitals, having increased from less than 10% in 2001.¹⁷ This suggests that the results of this study correctly reflect the situation in Dutch nursing homes and hospitals. Third, since only Dutch healthcare organisations with a structured patient handling programme including the presence of ergocoaches were included in this study, some caution is needed as regards the generalisability of the study results to other countries. Fourth, nurses may have provided socially desirable answers to questions during the short interview. It is, therefore, possible that the proportion of nurses motivated to use ergonomic devices during patient handling activities is overestimated. Nurses were, however, not aware of the fact that the actual use of ergonomic devices was assessed during real-time observations. During the short interview afterwards they were asked for their opinion on ergonomic device use. However, it may be that answers on motivation were influenced by actual use. Fifth, the definition of required use was based on the level of functional mobility of the patients. The cognitive capabilities of the patients, as well as their attitudes or preferences towards ergonomic devices, could have influenced the observed actual use of ergonomic devices. In this study, attitude and preferences were not determined. Sixth, in this study the terms ergonomic and lifting devices are used without providing detailed information as to their effects on postural load. It was not evaluated whether these devices were designed appropriately with regard to the intended reduction in postural load. Finally, to determine the necessity of ergonomic devices, the patients were categorised into three levels of functional mobility. The actual use of ergonomic devices could have been influenced by differences in the patients within these three levels.

This study shows that three determinants were strongly associated with lifting devices use during the transfer of a patient. First, the motivation of nurses to use lifting devices was strongly associated with increased lifting device use during the transfer of a patient. Several intervention studies have identified lack of motivation as a barrier to the successful implementation of lifting devices in healthcare.¹⁶ Motivation can be influenced by several different factors. In the present study three organisational factors were moderately associated with motivation of nurses to use lifting devices: a favourable ratio of lifting devices per patient on the ward, lifting devices available close to patients, and management maintenance ergonomic devices, with spearman correlations of 0.15, 0.14, and 0.20, respectively. This indicates a managerial influence on nurses adopting the behaviour to use lifting devices when required by making sure that enough lifting devices are available in proportion to patients on the ward, by providing easily available lifting devices, and by ensuring good maintenance. Evanoff et al. as well as Lynch and Freud have previously reported that the lack of availability of lifting devices was perceived as a barrier of successful implementation of lifting devices in healthcare.^{27, 28} Ceiling lifts instead of floor lifts might be a solution, since these lifting devices are always in the room of the patient and available for use. Alamgir et al. reported that staff preferred to use ceiling lifts for transferring and also found them less physically demanding.²⁹

Moreover, their study showed that transfers performed with ceiling lifts compared to floor lifts required on average less time and were found more comfortable for patients.

Second, the availability of patient specific protocols with strict guidelines for ergonomic device use was strongly associated with lifting device use. These protocols that incorporate requirements on safe patient handling into the daily care of patients mean that the way a patient is assisted is no longer largely determined by the individual nurse. A policy of mandatory use of equipment was also reported as facilitate the implementation of ergonomic devices in healthcare by Evanoff et al. and Charney et al.^{27, 30} Patient specific specific protocols with strict guidelines for ergonomic device use were available in 65% of the nursing homes but only 4% of the hospitals in this study. The low percentage in hospitals can partly be partly explained by rapid improvements in functional mobility in patients who usually stay in hospital for only a few days. In this study four organisational factors were associated with the availability of patient specific protocols with strict guidelines for ergonomic device use: management ensuring ergonomic devices were maintained ($r=0.21$), management reserving money for activities or supplies to reduce physical load ($r=0.40$), regular checking of the availability of ergonomic devices in proportion to the mobility of patients ($r=0.21$), and a policy on the maintenance of ergonomic devices ($r=0.16$). This indicates that the commitment of employers to the use of ergonomic devices has a positive influence on the availability of patients specific protocols with strict guidelines for ergonomic device use.

Third, the presence of back complaints in the past 12 months resulted in higher lifting device use among nurses. Apparently, having had back complaints triggers nurses to use lifting devices when required. Lifting devices are, however, intended to prevent both the onset as well as the recurrence of back pain episodes. Thus, nurses without back complaints should be encouraged to use lifting devices when required in order to prevent the onset of these complaints. Although the national practice guidelines advise the use of lifting devices for all nurses, whether or not they have back complaints, compliance with these guidelines is obviously far from optimal.

The use of lifting devices when required was much higher in nursing homes than in hospitals (72% vs 43%). The study by Evanoff et al. also showed higher compliance in using lifting devices in long term care facilities compared to hospitals (38% vs 15%).²⁷ Yassi et al. mentioned the rapidly changing patient population in hospitals as a barrier in the implementation of lifting devices.³¹ Our results, however, indicate that individual and organisational determinants within specific organisations are more important than differences between healthcare branches. In the multivariate analysis, the influence of type of branch on lifting device use disappeared when adjusted for the difference in motivation of the nurses to use lifting devices (63% vs 27%) and the availability of patient specific protocols with strict guidelines for ergonomic device use (65% v 4%). Also, in hospitals motivation of nurses to use lifting devices and the availability of patient specific protocols with strict guidelines for



ergonomic device use influenced required lifting device use, despite the rapidly changing patient population.

For patient handling activities other than transfers, none of the determinants had any association with required ergonomic device use. Other factors, not assessed in this study, may have had an influence. With regard to the use of sliding sheets, McGill and Kavcic concluded that the worker's personal technique and movement strategy is a critical determinant of back load in the use of these devices.¹¹ Pompeii et al. reported that about a quarter of patient handling injuries resulted from repositioning patients in bed.³² Thus, training in the use of sliding sheet use might help nurses to actually use the sliding sheets in order to prevent the occurrence of back complaints due to repositioning patients in the bed. The lack of manoeuvring space, mentioned by Li et al. and Pompeii et al. as a barrier to lifting device use, might also be a barrier to shower chair use during personal care.^{32, 33} Another possible explanation for the lack of association could be that our study did not have enough power due to fewer observations of other patient handling activities.

In conclusion, the use of lifting devices was higher in nursing homes than in hospitals. The use of lifting devices when required was strongly associated with motivation among nurses to use lifting devices and experienced back complaints in the past 12 months, as well as the availability of patient specific protocols with strict guidelines for ergonomic device use. This study demonstrated that barriers have a strong effect on the use of lifting devices. Individual and organisational factors seem to have considerable influence on whether ergonomic interventions will indeed contribute to a reduction in physical load in the workplace.

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Chapter



The influence of individual and organisational factors on nurses' behaviour to use lifting devices in healthcare

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ABSTRACT

Aims This study evaluates the influence of individual and organisational factors on nurses' behaviour to use lifting devices in healthcare.

Methods Interviews among nurses were conducted to collect individual characteristics and to establish their behaviour regarding lifting devices use. Organisational factors were collected by questionnaires and walk-through-surveys, comprising technical facilities, organisation of care, and management-efforts. Generalized-Estimating-Equations for repeated measurements were used to estimate determinants of nurses' behaviour.

Results Important determinants of nurses' behaviour to use lifting devices were knowledge of workplace procedures (OR=5.85), strict guidance on required lifting devices use (OR=2.91), and sufficient lifting devices (OR=1.92). Management-support and supportive-management-climate were associated with these determinants.

Conclusions Since nurses' behaviour to use lifting devices is influenced by factors at different levels, studies in ergonomics should consider how multi-level factors impact each other. An integral approach, addressing individual and organisational levels, is necessary to facilitate appropriate implementation of ergonomic interventions, like lifting devices.

INTRODUCTION

Among nurses, low back pain is a common musculoskeletal disorder.¹⁻³ A significant proportion of back pain episodes can be attributed to events that occur during patient handling activities when nurses are exposed to heavy lifting, awkward back postures, and pushing and/or pulling.³⁻⁵

In the past years, many ergonomic interventions have been developed, like lifting devices, to reduce mechanical load related to patient handling activities in order to (partly) decrease the occurrence of low back pain. The efficacy of lifting devices designed to reduce mechanical load has been demonstrated in several laboratory studies.^{6, 7} However, the timely and integrated implementation at the workplace remains difficult. Various intervention studies have indicated that individual behaviour of nurses is a key factor in successful implementation of lifting devices in healthcare.⁸ As examples, Evanoff et al. and Li et al. identified the lack of perceived need to use lifts as an important barrier in the effectiveness of lifting devices at the workplace.^{9, 10} Nelson et al. showed that acceptance of patient handling equipment by the staff was a crucial facilitator in the implementation process of a multiple intervention aimed at patient handling in healthcare.¹¹ A previous study in hospitals and nursing homes showed that individual behaviour of nurses, i.e. nurses' motivation to use lifting devices, was strongly associated with lifting devices use.¹² This study also pointed at the influence of organisational-level measures on nurses' behaviour, comprising both factors in each ward as well as at the managerial level of the healthcare institute. Thus, the appropriate implementation of ergonomic devices requires a careful process whereby individual behaviour is supported by organisational measures in order to enable and support the individual to adopt the required behaviour to prevent musculoskeletal complaints. A recent systematic review corroborated that upstream organisational strategies had a profound impact on musculoskeletal health.¹³ This important principle has been stressed also in adjacent areas in healthcare, such as patient safety, whereby it is important to consider how factors at different levels, for example nurses, wards, and organisations, interact to impact safety outcomes such as adverse drug events and patient harm.¹⁴

Individual factors can be identified directly in a traditional analysis of the influence of individual characteristics on the use of lifting devices. However, organisational factors at different levels in a healthcare institute, such as patient's room, ward, and organisation, are hierarchically linked and, therefore, cannot be analysed without taking into account their interdependency. In order to gain more insight into the interrelationship between individual and organisational barriers and facilitators of behaviour among nursing personnel to use lifting devices, a survey was conducted across hospitals and nursing homes in the Netherlands. The particular aim of this study was to evaluate the influence of individual and organisational factors on the individual behaviour of nurses to use lifting devices when required during transfer activities with patients in healthcare.



METHODS

Study population

The present cross-sectional study took place in 19 nursing homes and 19 hospitals with a structured patient handling programme. This programme is centered around the presence of an ergocoach at each ward. This is a nurse or nursing aid trained and specialised in ergonomic principles, who is responsible for supporting the process of working according to ergonomic principles in his ward. Their activities include being available for questions from colleagues, identifying problems, contributing to workplace improvements, and training personnel.¹⁵

In total, 41 nursing homes and 42 hospitals were approached with written information about the study purpose with a supportive letter of the national organisation in the health-care sector responsible for training and support of ergocoaches. A subsequent visit was paid to each organisation in order to explain aims and time constraints of the study in more detail. Eventually, 19 nursing homes (response 46%) and 19 hospitals (response 45%) decided to participate. Primary reasons for non-participation were lack of time, merger of the facility, and construction work in the facility.

In the Netherlands there are two types of nursing homes. First, the home which is destined for long term care for elderly who are not able to live entirely independent ($n=10$). The home for elderly provides general support for uncomplicated nursing care for physical, psychogeriatric, or psychosocial problems as a result of old age. Second, the home that is intended for people who need specific nursing care, residential care or revalidation as a result of disease, disorder, or old age but no longer need specialized medical care in a hospital ($n=9$). This study took place also in general hospitals in wards with a patient population staying at least a couple of days.

The data collection was carried out between 2007 and 2009. Individual factors of behaviour of nurses and nursing aids (hereafter referred to collectively as nurse) with regard to lifting devices were collected by a short interview ($n=238$). Each nurse was asked about age, presence of back complaints, presence of any other musculoskeletal complaints, work experience, and typical behaviour regarding lifting devices. At the organisational level, ward characteristics and policies were collected by means of a self-administered questionnaire filled out by the team leader of the ward, activities of the ergocoach was gathered through a self-administered questionnaire for ergocoaches, and institutional characteristics and policies were collected by means of a self-administered questionnaire filled out by the manager. A checklist was completed by researchers during a walk-through survey of all participating wards ($n=107$) and patient's rooms within each ward. The checklist was filled out before observations on individual nurses were conducted. In this list information was collected on storage location of lifting devices, location of bathroom towards patients' room, presence of patient specific protocol for lifting devices use, number of lifting devices, number of patients, number of nurses, and number of ergocoaches. Overall, 107 team leaders, 38 managers, and

193 ergocoaches filled out a self-administered questionnaire and an additional 107 checklists were filled out by researchers.

Informed consent was obtained verbally from all nursing homes and nurses prior to the study in accordance with the requirements for non-identifiable data collection in the Dutch Code of Conduct for Observational Research (www.federa.org).

Behaviour and individual factors

The structured interviews with nurses were based on a Dutch questionnaire on behavioural aspects with sufficient consistency validity per behavioural group of 0.55 to 0.67 (Cronbach's α) in a different application.¹⁶ A theory of planned behaviour was used to distinguish different stages in individual behaviour with respect to use of lifting devices.¹⁷ Six questions were used to identify the six consecutive stages of planned behaviour, varying from paying attention to the offered information to maintenance of the new behaviour.¹² Since some answering categories had low numbers, these six stages of behaviour were categorised into three mutually exclusive behavioural groups: intended behaviour, changed behaviour, and maintenance of behaviour. In the statistical analysis the first two groups were collated.

Individual characteristics were age (in years), work experience (in years), presence of low back pain in the past 12 months, and presence of any musculoskeletal complaint in the past 12 months.¹⁸ The ability of nurses to adopt usage of lifting devices was assessed by work experience and knowledge about existing workplace guidelines.¹² Age and working experience were dichotomised and median values were used as the cut off.

Organisational factors

Information about organisational factors was obtained at the level of the institute, ward, as well as the patient's room, in order to consider differences between and within the organisations and between and within wards. These organisational factors were selected from a systematic review on determinants of implementation of primary preventive interventions on patient handling in healthcare.⁸ The factors were categorized according to the scheme presented by Shain and Kramer.¹⁹

At the level of the healthcare institute, management support was ascertained with three questions related to the commitment of employers to the lifting devices. This was obtained through self-administered questionnaires by managers. At the level of each ward management climate and general support was measured by questionnaires filled out by the ward's team leader and by the ergocoach. The management climate was regarded as supportive when the need for use of lifting devices was regularly enforced. General support was characterized by the specific role of the ergocoach, distinguishing three key roles in innovation processes: knowledge manager, linkage agent, and capacity builder.²⁰ Each role was characterized by 4 activities measured on a five point scale, sum scores were calculated, and a score above median within each key role indicated the ergocoach performed this role. It must be stated



that the distinguished three roles were not mutually exclusive and, thus, an ergocoach could conduct several roles. The role as knowledge manager (who creates, diffuses and uses knowledge and skills and facilitates or manages these activities) was defined by the following four activities: 1) giving colleagues advice in the field of mechanical load, 2) addressing colleagues who fail to work the proper way, 3) giving colleagues positive feedback when working the proper way, and 4) giving colleagues suggestions about which and when ergonomic devices should be used during lift and transfer activities (Cronbach's α 0.82). The role as linkage agent (who focuses on the interface between creators and users of knowledge and skills and seeks to foster links between the two) was defined by the following four activities: 1) detecting and resolving barriers in the field of mechanical load, 2) discussing the planned activities in the field of mechanical load with the team leader, 3) conferring the progress of the introduction of and compliance with the national practical guidelines with the team leader, and 4) advising the team leader about adjustments in the policy of mechanical load (Cronbach's α 0.85). The role as capacity builder (who enhances access to knowledge and skills by providing training to knowledge and skills users which may lead to positive social outcomes) was defined by the following four activities: 1) giving training or instructions in ergonomic devices use, 2) giving training or instructions in lift and transfer techniques, 3) organising training or instructions in ergonomic devices use and lift and transfer techniques, and 4) checking if new colleagues are being instructed in the field of mechanical load (Cronbach's α 0.85).

At the level of a patient's room, technical facilities were evaluated through a checklist, focusing on availability, convenience, and easily accessibility of lifting devices. These facilities included the presence of sufficient lifting devices in the close vicinity of the bed. In addition, it was ascertained whether in the patient's care protocol specific guidance was stipulated on how patient transfer activities should be conducted for those patients with a reduced mobility.¹⁵

Data analysis

The influence of individual and organisational factors on sustained behaviour of nurses to use lifting devices during patient transfers was analysed by logistic regression analysis with generalised estimating equations (GEE), suitable for the analysis of measurements with a hierarchical structure. The odds ratio (OR) was used as measure of association, and an OR >1 indicates a positive influence of a specific factor on the individual behaviour of nurses.

The following procedure was used to identify determinants of nurses' sustained behaviour to use lifting devices. First, all individual, patient's room, ward, and institutional variables were analysed in univariate models. The variables with a p-value less than 0.10 were selected for further investigation. Second, a multivariate model with individual and organisational variables as independent variables was constructed by forward selection. Variables with a p-value less than 0.10 were retained in the final model. The interrelationships between different hierarchical levels in the organisation, namely patient's room, ward and institute, were

analysed with spearman correlation coefficients. Statistical analyses were performed using Proc Genmod in the statistical package of SAS version 9.2 software (SAS Institute, Cary, NC, USA).

RESULTS

Table 1 presents the characteristics of the study population, which consisted predominantly of women. The 12-month prevalence of back complaints was 42 to 45% and of any musculoskeletal disorders 58% to 64%. Nursing homes and hospitals differed considerably with respect to number of wards, number of workers, and number of patients per ward. The ratio of patients per full time equivalent nurses per ward ranged from 0.3 to 7.8 for nursing homes and for hospitals from 0.2 to 2.3.

Two-thirds of the nurses in nursing homes were classified as having sustained behaviour to use lifting devices when required during transfer activities with patients (table 2). In hospitals, only a quarter of the nurses sustained their behaviour to use lifting devices. Nursing homes more often had a favourable ratio of lifting devices per patients and presence of patient specific protocols for lifting devices use than hospitals. Supportive management

Table 1 Organisational characteristics of nursing homes and hospitals, ward characteristics and individual characteristics of nurses in these organisations in the study population.

Characteristics	Nursing homes	Hospitals
Institute	(n=19)	(n=19)
Number of wards per organisation, median (range)	4 (1-12)	29 (5-111)
Workers (fte) per organisation, median (range)	118 (26-400)	1600 (393-3000)
Patients per organisation, median (range)	126 (68-320)	453 (150-1070)
Number of observations of transfer activities where a lifting device was required*	145	80
Proportion of lifting devices use when required	72%	43%
Ward	(n=46)	(n=61)
Patients per ward, median (range)	30 (12-74)	19 (8-38)
Nurses (fte) per ward, median (range)	14 (4-62)	22 (10-64)
Ratio patient/fte nurses per ward, median (range)	2.1 (0.3-7.8)	1.0 (0.2-2.3)
Ratio fte nurses per peer leader (ergocoach), median (range)	9 (3.2-30.0)	13.5 (5.5-64.0)
Individual	(n=125)	(n=113)
Age, yrs, mean (SD)	37 (13)	32 (12)
Gender, female %	93%	94%
Working experience (years), median (range)	7 (0-43)	7 (0-40)
Back complaints in the past 12 months (%)	42%	45%
Any musculoskeletal complaints in the past 12 months (%)	58%	64%

fte=full time equivalent; *according to national practical guidelines



Table 2 Occurrence of individual and organisational factors at the level of the nurse, patient's room, ward and institute in nursing homes and hospitals.

			Prevalence	
Type	Category	Measurements	Nursing homes	Hospitals
Individual	Behaviour	Actual behaviour to use lifting devices:	8%	36%
		Attention through intention	29%	36%
		Changed behaviour	63%	27%
	Ability ^N	Maintenance of behaviour		
Patient's room	Ability ^N	Work experience	52%	49%
		Knowledge of workplace guidelines	98%	93%
	Interactivity ^R	Presence of patient specific protocol for lifting devices use	65%	4%
	Easily accessibility ^R	Bathroom attached to patients' room	61%	65%
	Availability ^R	Favourable ratio of lifting devices per patient	56%	33%
Ward	Convenience ^R	Lifting devices close to bed	11%	7%
	Supportive management climate ^T	Regular checking of amount of ergonomic devices in proportion to mobility of patients	95%	78%
		Policy on maintenance of ergonomic devices	94%	82%
		Mechanical load a regular topic in team meetings	73%	35%
	General support (Ergocoach) ^E	Knowledge manager	33%	39%
Linkage agent		50%	47%	
Capacity builder		53%	42%	
Institute	Management support ^M	Management spending money to maintain ergonomic devices	90%	47%
		Management reserving money for activities or supplies to reduce mechanical load	60%	49%
		Managers offering yearly training in the use of ergonomic devices	86%	80%

^Nstructured interview; ^Rchecklist filled out by researcher; ^Eself administered questionnaire of ergocoach; ^Tself administered questionnaire of team leader; ^Mself administered questionnaire of manager.

climate and management support were more common in nursing homes than in hospitals. The ergocoach in the role of capacity builder was most prevalent in nursing homes, whereas the ergocoach as linkage agent was most common in hospitals.

The univariate analyses shows that knowledge of the workplace guidelines and patient's room factors were important factors for nurses' sustained behaviour to use lifting devices during transfer activities with patients (table 3). Factors at the level of ward were not significantly associated with

nurses' behaviour. At the level of institutional management, spending money on maintenance of ergonomic devices was significantly associated with nurses' behaviour. In the multivariate model, individual factors as well as patient's room characteristics remained important for nurses' behaviour to use lifting devices. Knowledge of workplace guidelines, availability of patient specific protocols for lifting devices use, and a favourable ratio of lifting devices per

Table 3 The influence of individual and organisational factors at the level of the patient's room, the ward, and the institute on nurses' sustained behaviour to use lifting devices during transfer activities with patients in hospitals and nursing homes.

	Nurses' sustained behaviour to use lifting devices during transfer activities with patient			
	Univariate (N=238)		Multivariate	
	OR	95% CI	OR	95% CI
Individual				
Age less than 30 years	0.63	(0.31-1.29)		
Back complaints (in the past 12 months)	0.69	(0.34-1.41)		
Any musculoskeletal complaints (in the past 12 months)	0.81	(0.39-1.69)		
Work experience of 7 years or more	1.34	(0.66-2.73)		
Knowledge of workplace guidelines	9.24**	(1.72-49.63)	5.85**	(1.09-31.27)
Patient's room				
Availability of patient specific protocol for lifting devices use	3.87**	(1.96-7.65)	2.91**	(1.50-5.67)
Bathroom attached to patients' room	2.09*	(0.92-4.76)		
Favourable ratio lifting devices per patient	2.30**	(1.08-4.89)	1.92*	(0.89-4.16)
Lifting devices close to bed	7.99	(0.76-84.43)		
Ward				
Regular checking of amount of ergonomic devices in proportion to mobility of patients	0.78	(0.24-2.50)		
Policy on maintenance of ergonomic devices	1.01	(0.34-2.98)		
Mechanical load regular topic in team meetings	1.21	(0.57-2.59)		
Ergocoach as knowledge manager	0.73	(0.36-1.49)		
Ergocoach as linkage agent	0.65	(0.32-1.33)		
Ergocoach as capacity builder	0.85	(0.42-1.72)		
Institute				
Management spending money to maintain ergonomic devices	2.55**	(1.14-5.67)		
Management reserving money for activities or supplies to reduce mechanical load	0.72	(0.35-1.46)		
Managers offer yearly training in the use of ergonomic devices	0.62	(0.22-1.74)		

**p<0.05, *p<0.10, N=number of nurses, OR=Odds Ratio, 95% CI=95% Confidence Interval

patient were associated with sustained behaviour among nurses to use lifting devices with ORs of 5.85, 2.91, and 1.92, respectively.

Figure 1 shows the interrelationships between factors at different hierarchical levels in the organisation. Managerial decisions to reserve and spend money on maintenance of ergonomic devices and measures to reduce mechanical load were positively associated with ward characteristics, such as a procedure to regularly check the availability of ergonomic devices in proportion to the mobility of patients and a policy on maintenance of ergonomic devices. An institutional policy to provide yearly training for personnel in use of ergonomic devices supported the ergocoach as capacity builder. In turn, these factors in each ward positively influenced the inclusion of guidance for lifting devices use in a patient's care protocol and a favourable ratio of lifting devices per patient.

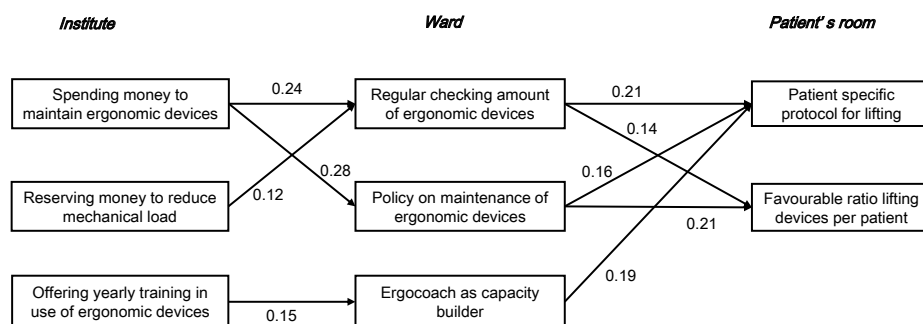


Figure 1 Simplified conceptual model of the contributions of individual and organisational factors to an appropriate use of lifting devices.

DISCUSSION

This study shows that nurses' behaviour, i.e. the motivation of nurses to use lifting devices during transfer activities with patients, was associated with knowledge of existing workplace guidelines, availability of sufficient lifting devices, as well as the presence of guidance on lifting devices use in a patient's care protocol. At higher hierarchical levels in the organisation, management support and a supportive management climate were associated with these factors supporting sustained behaviour among nurses.

There are a few limitations that must be taken into account in this study. First of all, the cross-sectional design of this study does not permit statements on causality of the associations between individual and organisational factors and nurses' behaviour to use lifting device. Second, selective participation compromising external validity might have occurred, since participation of nursing homes and hospitals was on a voluntary basis and targeting those that employed ergocoaches on wards. However, information from national surveys in 2008 showed that 85% of nursing homes have employed ergocoaches on wards.²¹ Information from national surveys among hospitals in 2005 showed that ergocoaches were present in 56% of the hospitals, having increased from less than 10% in 2001.¹⁵ This suggests that the results of this study adequately reflect the situation in Dutch nursing homes and hospitals. Third, since only Dutch healthcare organisations with a structured patient handling programme including the presence of ergocoaches were targeted in this study, some caution is needed with regard to the generalizability of the study results to other countries. Fourth, individual information was collected by interviewing nurses who may have provided socially desirable answers to the questions about their motivation to use lifting devices during transfer activities and their knowledge about workplace procedures. Thus, the proportion of nurses with sustained behaviour and good knowledge may be overestimated. Information at other levels was gathered by walk through surveys and by questionnaires. It is of interest to note that the factors in a patient's room that contributed to sustained behaviour of nurses were all collected by objective measurements.

This study showed that factual knowledge on workplace procedures on mechanical load as well as (technical) facilities had a direct influence on nurses' behaviour to use lifting devices. Knowledge of existing workplace guidelines was strongly associated with nurses' behaviour to use lifting devices. This is not completely unexpected, since this study took place in institutes with a structured approach for the prevention of musculoskeletal disorders including workplace guidelines. Apparently, knowledge is indeed important for nurses' behaviour to use lifting devices. Evanoff et al. also reported lack of knowledge as a barrier in the implementation of ergonomic interventions.⁹ Although, training as primary preventive intervention to decrease the occurrence of back pain seems not effective^{22, 23}, training could be used as a first step to increase knowledge in order to stimulate nurses' behaviour to use lifting devices. This survey showed that knowledge on workplace guidelines coincides with sustained behaviour to use lifting devices. Due to the study design, it is not possible to determine whether this knowledge is an important prerequisite for changing behaviour or whether a changed behaviour will sensitize nurses to the existence of workplace guidelines.

The direct physical environment of nurses, i.e. the availability of sufficient lifting devices against the number of patients, was also important for nurses' behaviour. This is in agreement with several intervention studies that have reported the working environment of nurses as barrier or facilitator in the implementation of ergonomic interventions.^{9, 24, 10, 25} Li et al. and Ronald et al. reported the lack of manoeuvring space and structure of the building as barriers in the implementation of lifting devices in hospitals in the USA and Canada.^{10, 25} Misplacement or lack of sufficient lifting devices was described as barrier in lifting devices use by Evanoff et al.⁹ Fujijshiro et al. reported a lower employee-to-ergonomic device ratio as facilitator in the implementation of lifting devices in nursing homes and hospitals in the USA.²⁴ The present study showed that a high availability of lifting devices most likely enhanced nurses' behaviour to use lifting devices. Availability of sufficient lifting devices should be incorporated in policies of management.

The presence of specific guidance on lifting devices use in a patient's care protocol was strongly associated with nurses' behaviour to use lifting devices as well. Protocols that incorporate requirements on safe patient handling into the daily care of patients will avoid that the way a patient is being assisted is no longer largely determined by the individual nurse. A policy of mandatory use of equipment was also reported as a facilitator of the implementation of ergonomic devices in healthcare by Evanoff et al. and Charney et al..^{9, 26} Thus, workplace policies are required that target mandatory use of lifting devices. The proportion of nurses with sustained behaviour on use of lifting devices differed substantially between nursing homes and hospitals, respectively 63% versus 27%. This could partly be explained by the rapid changing patient population in hospitals. Nurses may not have sufficient time to adopt their behaviour to the needs of a specific patient with regard to use of a lifting device during transfer. A changing patient population was also reported as important factor in the implementation of lifting devices by Yassi et al. and Evanoff et al..^{9, 27} Besides, due to the rap-



idly changing patient population in hospitals, patient's care protocol with specific guidance to stipulate lifting devices use were less present or not up to date most of the time. Another explanation for the observed striking difference in behaviour among nurses could be the size of the participating institutes. Nursing homes were small to medium-sized enterprises, whereas hospitals were typically large enterprises. More interaction may be present between management and individual nurses in smaller organisations.

Factors at the level of the ward and the institute were not directly associated with nurses' behaviour. The influence from these higher levels was less important than the direct facilities of nurses in influencing nurses' behaviour. There were, however, moderate interrelationships between more upstream factors at the level of the patient's room, the ward, and the institute. This indicates that management can create important conditions.¹³

A limited set of organisational factors was assessed in this study. It should not be ruled out that other factors could be of importance as well. In healthcare, the patient is an important external factor, encompassing the physical and cognitive capabilities of the patients, as well as the attitudes of the patients towards the intervention.⁹ Different studies have described the attitudes or preferences of patients towards lifting devices as important factor for nurses' behaviour to use lifting devices.^{11, 27, 28} In addition, attitudes of co-workers (social support) could have an impact as well. The factors time required to alter work culture and nurses wanting to transfer the patient "the old way" were described as barriers in intervention studies.²⁹ ³⁰ This study assessed the influence of general support by the presence of an ergocoach at each ward. However, no association with nurses' behaviour to use lifting devices was found. In a multifaceted ergonomics program to prevent injuries due to patient handling tasks peer leaders, known as Back injury Resource Nurses, played an essential role.¹¹ The peer leaders were ranked as extremely effective by 66% of the nurses, but their influence was not assessed separately in this study. Thus, more research is required on the influence of individual and organisational factors on behaviour.

The appropriate implementation of ergonomic devices is a complex phenomenon that can be influenced by various factors at different levels in a healthcare organisation. Individual as well as organisational factors were associated with nurses' behaviour to use lifting devices. The organisational factors were present at three different levels, i.e. the room, the ward, and the institution. Since there is a hierarchical structure (rooms within ward and wards within the institute), these organisational factors cannot be analysed simultaneously on the classical regression models and use of statistical models that take into account this hierarchical structures advocated. In addition, the interrelations between different levels should be analysed in order to evaluate the structural links between the chain of factors. The need to look at multiple levels in implementation research is not solely applicable to the ergonomic area. Karsh and Brown have emphasized for patient safety programs the need to study relationships among variables at different levels and to look across system levels so that the right interventions for the right situations are implemented.¹⁴ Thus, studies on ergonomics should

consider multi-level analyses to understand how variables at different levels interact. In conclusion, this study shows that an integral approach that addresses individual nurses, care procedures, and workplace policies is necessary to facilitate appropriate implementation of ergonomic interventions, such as lifting devices.

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PART



LONG TERM EFFECTS OF LIFTING DEVICES USE



Chapter



Assessment of the impact of lifting device use on the occurrence of low back pain among nurses

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Submitted



ABSTRACT

Objectives The aims of this study were: (1) to evaluate the effect of manually lifting patients on occurrence of low back pain (LBP) among nurses, and (2) to estimate the impact of lifting devices on prevention of LBP and injury claims.

Methods A literature search in Pubmed, Embase, and Web of Science identified studies with a quantitative assessment of the effect of manually lifting patients on occurrence of LBP and studies on the impact of introducing lifting devices on LBP and injury claims for musculoskeletal complaints (MSD). A Markov decision analysis model was constructed for a health impact assessment of patient lifting devices use in healthcare.

Results The scenario with a realistic representation of evidence, based on observational and experimental studies, showed a maximum reduction in LBP prevalence from 41.9% to 40.5% and in MSD injury claims from 5.8 to 5.6 per 100 work-years. Complete elimination of manually lifting patients would reduce the LBP prevalence to 31.4% and MSD injury claims to 4.3 per 100 work-years. These results were sensitive to the strengths of the association between patient lifting and LBP as well as the prevalence of patient lifting. The realistic variant of the baseline scenario requires well over 25,000 workers in healthcare to demonstrate effectiveness.

Conclusions This study shows that a good implementation of lifting devices is required to noticeably reduce LBP and injury claims. This health impact assessment may guide intervention studies as well as implementation of programmes to reduce manually lifting of patients in healthcare.

INTRODUCTION

The most common musculoskeletal disorder among nurses is low back pain (LBP).¹ A significant proportion of back pain episodes can be attributed to events that occur during patient handling activities, like pushing and/or pulling, awkward back postures, and lifting. It has been well documented that manual lifting is a risk factor for the occurrence of LBP.²⁻⁵

Lifting devices have been developed to reduce mechanical load related to manual lifting in order to decrease the occurrence of LBP. The efficacy of lifting devices has been assessed in a number of laboratory studies⁶⁻⁷ and some observational studies.⁸⁻⁹ However, the timely and integrated implementation in the actual work situation remains difficult. A number of design limitations and logistical barriers have hampered workplace studies of the effectiveness of lifting devices for reducing the occurrence of LBP.¹⁰ A crucial issue is the need for sufficiently long follow-up periods for intervention studies. While lifting devices can reduce mechanical load during transfer activities with patients, an important risk factor for LBP, a reduction in the occurrence of LBP may be a delayed response.¹¹ When intervention studies with sufficiently long follow-up periods are not available, quantitative health impact assessment is a powerful method to assess the potential effects of an intervention.¹²

In a health impact assessment the information from observational and experimental studies with limited time horizon may be used to predict the effect of introducing lifting aids in healthcare on the long-term course of LBP in nursing personnel. In this regard, a particularly useful technique is a Markov model of disease, which can be used for health events of discrete nature that happen more than once over time.¹³ A Markov model assumes that the subject is always in one of a finite number of health states, for example having symptoms or having no symptoms of LBP. The course of disease is modelled by transitions from one state to another during a specified period of time. Under the assumption that the transition probabilities are constant over time, a Markov chain may be created by repeating multiple cycles to represent a meaningful time interval, for example employment in the same job for 30 years or more. The impact of introducing lifting aids on occurrence of LBP in a hypothetical cohort of nurses can be modelled by adjusting the transition probabilities for the estimated effect of lifting aids on the occurrence of LBP.

The aims of this study were: (1) to evaluate the effect of manually lifting patients on the occurrence of LBP among nurses, and (2) to estimate the impact of lifting devices as intervention strategy on prevention of LBP.



METHOD

Available evidence

The health impact assessment simulates a cohort of nurses with 10 year follow-up period for the occurrence of LBP in the presence or absence of lifting devices for patient transfers. This model requires knowledge on (1) the course over time of occurrence of LBP among nurses, (2) the effect of manually lifting patients on occurrence of LBP, and (3) the impact of introducing patient lifting devices on the reduction in occurrence of LBP. Model parameters were based on reviews of published studies in Pubmed, Embase, and Web of Science. First, a literature search was conducted for original studies on the effect of manual lifting of patients on LBP among nurses. Table 1 presents the six cross-sectional studies, two longitudinal studies and one case-referent study with a quantitative measure of association between manual lifting of patients and the occurrence of LBP.¹⁴⁻²² The measure of association between manual lifting of patients and LBP ranged from 1.1 to 7.5. In two out of three studies with an ordinal expression of exposure no clear trend of increased occurrence of LBP with higher frequency of daily lifting patients was observed. The fraction of LBP attributed to manual lifting of patients varied between 0.01 and 0.60 in these study populations (table 1).

Second, a literature search was conducted for observational and experimental studies that describe the impact on introducing lifting devices in healthcare organisations on occurrence of LBP or musculoskeletal disorders. Studies were only selected if information was presented on the uptake of the invention, either by availability of lifting devices or by actual use of these devices. Table 2 summarizes the main findings of eight studies with a quantitative expression of the impact of lifting devices use on the occurrence of LBP or other measures of musculoskeletal problems.^{9, 23-29} The uptake of the intervention varied considerably, as well as the reported influence of health outcomes. Two studies clearly showed the complexity of evaluating the effects on this intervention with a substantial decrease in MSD injury claims in an intervention hospital, but no decrease in a second intervention hospital.^{9, 28}

Disease model and parameters

As first health measure LBP in the past 12 months was chosen, since it is a frequently used health outcome in observational studies on associations between mechanical load and LBP.³⁰ The second health measure was patient-handling injury claims, since several authors have suggested that a reduction in manually lifting patients will have a greater impact on lost work days than on occurrence of episodes of LBP.²³⁻²⁴

The disease model consisted of a Markov chain approach with one year increments of time during which a subject may make a transition from one health state to another.¹³ In the first step the occurrence of LBP in the past 12 months was simulated, whereby the events modelled over each cycle of one year include the annual probabilities that a nurse has a new episode of LBP after having been free from LBP at least one year (incidence), a repeated

Table 1 Associations between manually lifting patients and the occurrence of back pain among nurses in nine observational studies.

Author	Study population and design	Outcome measure	Exposure (% exposed)	Measure of association	Population attributable fraction
Arad et al., 1986 (14)	831 nurses (CS)	LBP in past month (42%)	≥6 patient lifts per shift (95%)	OR=2.5 (1.8-3.4)	58% (43%-70%)
Engkvist et al., 2000 (15)	854 nurses (CR)	Back injury in past 32 months (28%)	≥1 patient lifts per shift (88%)	OR=2.7 (1.6-4.5)	60% (35%-75%)
Landry et al., 2008 (16)	344 health professionals (CS)	Current LBP (22%)	Patient lifts: 1-5 times per day (43%) 6-10 times per day (22%) >10 times per day (16%)	OR=2.0 (1.4-2.8) OR=1.7 (1.1-2.7) OR=7.5 (5.2-10.8)	30% (15%-44%) 13% (2%-27%) 51% (40%-61%)
Lo et al., 1993 (17)	37 nurses (CS)	Current LBP (30%)	Patient lifts, for each additional 100 kg lifted	OR=1.1 (1.0-1.2)	1% (0%-3%)
Mandel et al., 1987 (18)	428 nurses (CS)	LBP for at least 2 days in past 12 months (15%)	>2 patient lifts per shift (50%)	OR=1.4 (1.1-1.8)	16% (2%-30%)
Smedley et al., 1995 (19)	1616 nurses (CS)	LBP in past 12 months (45%)	Patient lifts: 1-4 times per shift (33%) 5-9 times per shift (17%) ≥10 times per shift (21%)	OR=1.4 (1.1-1.9) OR=1.8 (1.3-2.5) OR=1.5 (1.1-2.1)	12% (3%-23%) 12% (5%-20%) 10% (2%-19%)
Stobbe et al., 1988 (20)	415 nurses (CS)	Back injury claim in past 40 months (17%)	>5 patient lifts per shift (76%) vs <2 times per shift	HR=2.4 (p < 0.05)	51%
Smedley et al., 1997 (21)	783 nurses (CO) 2 yrs follow-up	LBP during follow-up (38%)	Patient lifts: 1-4 times per shift (33%) 5-9 times per shift (14%) ≥10 times per shift (19%)	OR=1.3 (0.9-1.7) OR=1.6 (1.1-2.3) OR=1.6 (1.1-2.3)	9% (-3%-19%) 8% (1%-15%) 10% (2%-20%)
Venning et al., 1987 (22)	4306 nurses (CO) 1 yrs follow-up	LBP injury claim in past 12 months (2.9%)	≥1 patient lifts per day (44%)	OR=2.2 (p < 0.05)	34%

OR=Odds Ratio, HR=Hazard Ratio, CS=cross-sectional study, CR=case-referent study, CO=prospective cohort study.



Table 2 Experimental and longitudinal studies on the impact of lifting devices use on the occurrence of back pain among nurses.

Author	Study design	Study population	Intervention	Uptake of intervention	Measure of effect	Effect
Schoenfisch et al., 2012 (9)	Interrupted time series (13 years)	11545 caregivers (hospital 1 83%, hospital 2 17%)	Lifting and handling equipment	Availability of at least one portable lift per unit between 63% and 100% over time	MSD injury claims per 100 fulltime workers per year	Hospital 1: 0% decrease, rate last year = 3 per 100 Hospital 2: 44% decrease, rate last year = 4.8 per 100
Evanoff et al., 2003 (23)	Pre-post design (follow-up 2-3 years)	36 nursing units in hospital and nursing homes	Full-body and stand-up lifts and instructional courses	20% use of mechanical lifts in previous shift	Patient-handling MSD injury claims per 100 fulltime workers per year	Lift use: 6.3 to 5.5 Non-lift use: 6.3 to 6.7
Garg et al., 2012 (24)	Pre-post design (follow-up 36-60 months)	853 nursing staff in 7 long-term care facilities and hospital	Integral programme with no-manual lifting policy	Availability of at least one total-lift hoist and one sit-stand hoist per unit with a maximum of 8 patients	Patient-handling MSD injury claims per 100 fulltime workers per year	24.4 to 9.8
Knibbe et al., 1999 (25)	Pre-post design with control group (1 year)	Home care INT: 139 nurses CON: 239 nurses	Integral programme including 40 patient hoists	Manual transfers per nurse per week INT: 35.0 to 21.3 CON: 23.5 to 23.8 Hoist use per nurse per week INT: 25% to 57% CON: 28% to 28%	LBP in past 12 months	INT: 74% to 64% ($p < 0.05$) CON: 62% to 66%
Nelson et al., 2006 (26)	Pre-post (follow-up 9 months)	825 nursing staff in 7 home care facilities and hospitals	Integral programme including lifting and other devices	Unsafe patient handling per day PRE to POST 14% decrease ($p = 0.03$)	Patient-handling MSD injury claims per 100 fulltime workers per year	24.0 to 16.9
Smedley et al., 2003 (27)	Pre-post (follow-up 32 months)	Hospital INT: 817 nurses CON: 340 nurses	Lifting and handling equipment and sliding sheets	Number of patient handling activities without mechanical aids per shift INT-1: 3.5 to 3.2 CON: 3.3 to 2.6	LBP in past month	INT: 27% to 30% CON: 27% to 27%
Yassi et al., 2001 (28)	RCT (follow-up 1 year)	Hospital INT-1: 116 nurses INT-2: 127 nurses CON: 103 nurses	No strenuous lifting program including mechanical and other transfer equipment	Number of patient handling tasks without mechanical aids per shift CON: 33 (± 23) to 32 (± 30) INT-1: 31 (± 23) to 23 (± 20) ($p < 0.05$) INT-2: 39 (± 29) to 29 (± 26) ($p < 0.05$)	Patient-handling MSD injury claims per 100 fulltime workers per year	CON: 2.8 to 3.8 INT-1: 2.5 to 2.7 INT-2: 4.1 to 3.1
Zadvinskis et al., 2010 (29)	Pre-post (follow-up 1 year)	Hospital INT: 46 nurses CON: 29 nurses	Minimal-lift policy including floor-based lift and stand-assist device	Frequency of equipment use per day (posttest only) INT: 0.8 floor-based lift, 0.6 stand-assist device CON: no use	Patient-handling MSD injury claims in 12 months	INT: 7 to 3 CON: 6 to 5

INT=intervention group; CON=control group; LBP=low back pain; MSD=Musculoskeletal disorders; MSI=Musculoskeletal injuries.

episode of LBP from one year to another year (recurrence), recovers from LBP by having at least one year free of LBP (recovery), or leaves work due to becoming permanently work disabled due to LBP. The latter health state was considered an absorbing state, i.e. transition to another state from within this state is regarded to be impossible. These LBP states were enumerated in such a way that, in any given year, an individual was in one health state only and that the probabilities of the three non-absorbing states sum up to 1. Subsequently, among those nurses with LBP in a given year, the likelihood of a patient-handling related injury claim in that same year was incorporated in the model. In the second step the impact of lifting devices was introduced by the assumption that use of lifting devices will result in a decreased incidence of LBP, reflected in a reduced probability of an incident episode of LBP. The probabilities for recurrence and recovery were not changed. All transition probabilities were assumed to be constant over time, i.e. the transition from one health state to another health state in a given year is independent from the health status in earlier one year cycles.

Model parameters were derived from the available evidence presented in tables 1 and 2. In a large cross-sectional study among nurses the prevalence of LBP was 45%,¹⁹ and from the subsequent longitudinal follow-up an annual incidence of 25%, recurrence of 66%, and recovery of 34% were estimated.²¹ The annual transitional probability from LBP to becoming permanently work disabled due to LBP was set at 1.37 out of 1000 workers with LBP, based on disability statistics in the Netherlands. From table 1, four studies with comparable definitions were pooled to estimate an exposure prevalence for manually lifting at least one patient per shift of 57% (95% Confidence Interval 56%-58%) and an odds ratio (OR) of 2.07 (95% CI 1.65-2.50).^{15, 16, 19, 22} Based on 6 studies in table 2, a pooled estimate of MSD injury claims prior to the intervention was calculated, resulting in 6.2 claims per 100 worker-years (95% CI 5.8 - 6.6).^{9, 23-24, 26, 28-29}

In order to estimate the proportional reduction in the annual incidence of LBP due to a specific reduction in the exposure, the potential impact fraction (PIF) was calculated with the formula

$$PIF = (P - P') (OR - 1) / P (OR - 1) + 1,$$

where by P represents the prevalence of exposure in the study population before the intervention, P' the prevalence of exposure after introducing lifting devices, and OR the association between manually lifting patients and LBP.³¹ Note that the OR was used as approximation of the relative risk. The PIF will equal the population attributable fraction, presented in table 1, when the exposure to lifting patients manually is completely eliminated. Applying this formula to the model parameters described above, complete elimination would result in a PIF of 0.38 and a consequent decrease in the annual incidence of LBP from 25.0% to 15.5%. However, studies in real life situations have found the reduction in manual lifting of patients to be substantially less, as is shown by studies in table 2. Three studies with comparable defi-



nitions of exposure showed a pooled reduction in the prevalence for manually lifting at least one patient per shift of 16% (95% CI 13.5%-17.6%).^{25, 27-28} In the health impact assessment model this relates to a PIF of 0.06, indicating that approximately 6% of all LBP cases will be prevented by implementing lifting devices.

Simulations and sensitivity

A simulation was carried out with two hypothetical cohorts of nurses. In the first cohort nurses will enter their job without a history of LBP. The second cohort consists of nurses already working in healthcare with an overall prevalence of LBP of 45%. Both cohorts will be followed up for a period of 10 years.

Three scenarios of the intervention were evaluated for their impact on LBP and MSD injury claims (see table 3). For each scenario the realistic variant reflects the evidence available from observational and experimental studies, and the maximum variant provides the maximum gain to be achieved with complete elimination of manual lifting of patients. The baseline scenario assumes an annual incidence of LBP of 25%, recurrence of 66%, and recovery of 34%, about 57% of all nurses involved in manually lifting patients at least once a day, and an OR of 2.07 for patient lifting and incident LBP. In the second scenario the annual incidence of LBP is

Table 3 Sensitivity of different scenarios for the impact lifting devices in healthcare on the annual prevalence of LBP and MSD injury claims in a hypothetical cohort of newly hired nurses during a 10 year follow-up period.

Scenario	Scenario variant	Change in parameter	Annual prevalence of LBP		Annual MSD injury claims per 100 workers	
			without lifting devices	with lifting devices	without lifting devices	with lifting devices
Baseline scenario	Realistic: PIF = 0.06		41.9%	40.5%	5.8	5.6
	Maximum: PIF = 0.38		41.9%	31.4%	5.8	4.3
Second scenario	Realistic: PIF = 0.06	Annual incidence of LBP from 25% of 20%	36.7%	40.5%	5.1	4.9
	Maximum: PIF = 0.38		36.7%	26.8%	5.1	3.7
	Realistic: PIF = 0.06	Annual incidence of LBP from 25% of 30%	46.2%	40.5%	6.4	6.2
	Maximum: PIF = 0.38		46.2%	35.4%	6.4	4.9
Third scenario	Realistic: PIF = 0.04	Odds ratio from 2.07 to 1.65	41.9%	40.9%	5.8	5.6
	Maximum: PIF = 0.27		41.9%	34.8%	5.8	4.8
	Realistic: PIF = 0.07	Odds ratio from 2.07 to 2.50	41.9%	40.2%	5.8	5.5
	Maximum: PIF = 0.46		41.9%	28.5%	5.8	3.9

PIF=potential impact fraction

changed by 5% points. In the third scenario the association between patient lifting and LBP is varied according to the confidence intervals of the pooled estimate, thus using OR values of 1.65 and 2.50. As a consequence, the PIFs in the “realistic” variant will be 0.04 and 0.07, respectively, and PIFs in the maximum variant 0.27 and 0.46, respectively.

The sensitivity analysis determined to what extent the assumptions underlying these scenarios influenced the outcome of the health impact assessment. For all 10 possible combinations the impact on LBP and MSD injury claims about 10 years after start of the intervention was estimated. In addition, for those combinations with the highest change in LBP prevalence a power analysis was conducted to illustrate the required number of nurses in the intervention population in order to detect the estimated reduction in prevalence of LBP.³²

RESULTS

Figure 1 depicts the simulation of the natural course of LBP among nurses entering their job without a history of LBP and among nurses already working in healthcare. In the cohort of newly hired workers the prevalence of LBP quickly increased in the first 4 years and after 6 years remained stable at approximately 42%. In the cohort of current workers the prevalence dropped slightly in the first few years and after 6 years was similar to the prevalence among newly hired workers. The baseline scenario with a realistic representation of evidence showed a maximum reduction in LBP prevalence from 41.9% to 40.5% after 10 years. The maximum variant of this scenario with complete elimination of manually lifting patients reduced the

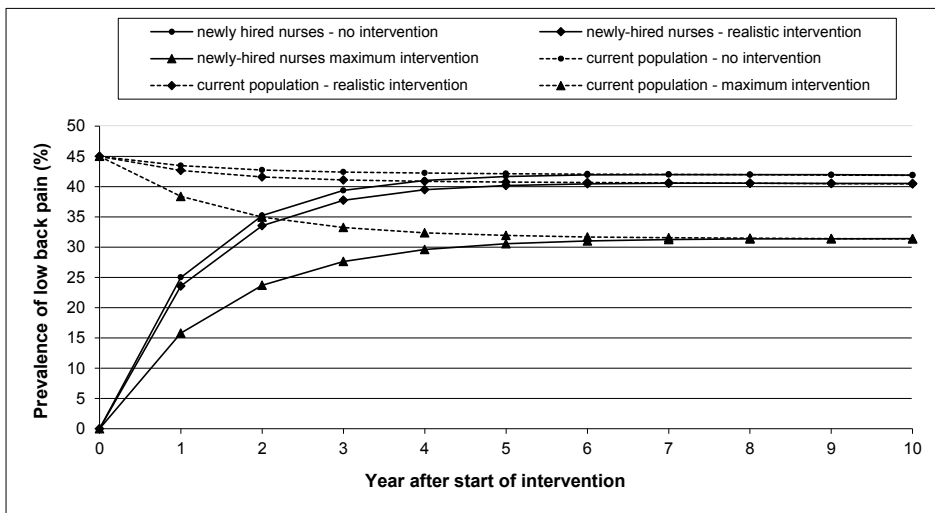


Figure 1 Simulation of the natural course of LBP among nurses entering their job without a history of LBP and among nurses already working in healthcare and the potential effects of implementation of lifting devices.

LBP prevalence from 41.9% to 31.4%. It is of interest to note that the impact of the intervention attenuated over time to a maximum influence after 6 years.

Table 3 summarizes the impact of different scenarios and assumptions on LBP and MSD injury claims. Since both cohorts had very similar results, only information among newly hired nurses is presented. Changes in the annual incidence of LBP had a substantial influence on the estimated burden of disease, but did not influence the impact of the intervention. For example, the change in annual incidence of LBP from 20% to 30% resulted in a similar increase in annual prevalence of LBP from 36.7% to 46.2%, and increase in annual MSD injury claims from 5.1 to 6.4. However, the estimated impact of the lifting devices on reduction in prevalence of LBP varied between 9.9% and 10.8% and corresponding figures for MSD injury claims were 1.4 and 1.5.

A change in the magnitude of the association between patient lifting and LBP had a considerable influence. A higher OR implicated a higher potential impact fraction and, as illustrated in table 3, larger health gains. With a change in OR from 1.65 to 2.50, the maximum reduction in prevalence of LBP rose from 7.1% to 13.4% and the reduction in MSD injury claims from 1.0 to 1.9.

Figure 2 presents the power analysis for the combinations with the highest potential impact fractions on the required number of nurses in the intervention population to be able to demonstrate a statistically significant effect of introducing lifting devices on the annual prevalence of LBP. In the best scenario with a PIF of 0.46 about 350 nurses need to be included to demonstrate an impact in a longitudinal study with one year follow-up. Longer follow-up periods will decrease the required sample size, but after 4 years there are no gains to be made. In the realistic variant of the baseline scenario with a PIF of 0.06, these numbers

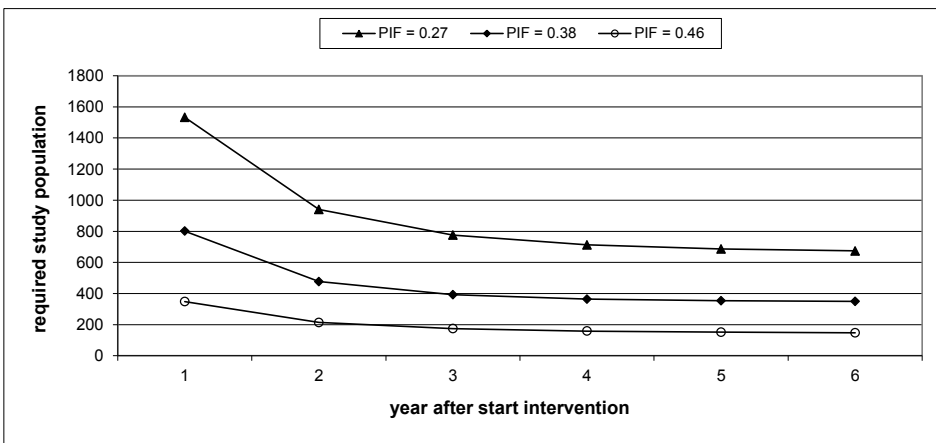


Figure 2 Required number of newly hired nurses in the intervention population to demonstrate a statistically significant effect on the prevalence of LBP for three different estimates of the potential impact fraction (PIF) of the implementation of lifting devices.

were 42,100 and 25,700, respectively (not shown). For MSD injury claims even larger numbers of nurses are required for studies with sufficient power.

DISCUSSION

This health impact assessment on the effect of lifting devices use for patient transfers in healthcare demonstrates that the impact of this intervention depends strongly on the proportion of LBP that is attributable to manual lifting of patients (how much can be avoided?) and on the success of strategies to reduce the proportion of nurses involved in manually lifting patients (how much exposure reduction can be achieved?). The synthesized evidence from observational and experimental studies suggests that implementation of patient handling devices in healthcare will not result in a noticeable reduction of LBP or MSD injury claims unless such implementation results in a substantial decrease in manual lifting of patients. Given the reported change in exposure to manually lifting patients, several intervention studies were severely underpowered to demonstrate the effectiveness of lifting devices in healthcare. Likewise, those studies that have reported a substantial decrease in MSD injury claims have most likely succeeded in eliminating most manual patient lifting by nurses.

The results of this health impact assessment seem to mirror findings reported in the literature. The intervention studies in table 2 showed large differences in impact on occurrence of LBP or MSD injury claims, varying from 0%⁹ to almost 60%.²⁴ An important explanation for these strongly varying findings is the integrity of the intervention, especially the incomplete uptake of the intervention. Three intervention studies have pointed at the limited use of the available lifting equipment as possible reason for lack of reduction in musculoskeletal injury claims^{9,28} or prevalence of LBP.²⁷ Recent studies on primary preventive interventions on patient handling in healthcare have identified many barriers at individual and organisational level that hampered appropriate implementation.^{33, 34} A second important explanation is the uncertainty in the proportion of LBP that is caused by manually lifting patients. In the observational studies presented in table 1, the fraction of LBP attributed to manual lifting of patients varied between 1% and 60%. In the disease model a population attributable fraction was used of 38%, which seems reasonable in the light of the population attributable fractions between 27% and 34% in the two longitudinal studies included in table 1.^{21, 22} In a meta-analysis lifting as occupational risk factor for LBP accounted for approximately 33% to 39% of all LBP episodes in the workforce.³

This health impact assessment shows that programmes to reduce patient lifting in healthcare will only be effective when manual patient lifting is almost completely phased out. This requires a careful development and implementation of such a programme with ample attention for barriers often mentioned, such as employee motivation, convenience and easy accessibility of devices, supportive management climate, and workers' involvement.^{24, 33} The



scenario with the highest effects due to elimination of manual lifting predicted a relative reduction of approximately 33% in the prevalence of LBP and MSD injury claims. Our model could not distinguish well between onset of LBP, aggravation of LBP in terms of chronicity and recurrence, and consequences for productivity loss due to work days lost and modified work. In a cost-benefit analysis the indirect costs will be of paramount importance. A recent study in two large hospitals in the US reported that patient-handling activities contributed to 72% of all MSD injuries and 53% of compensation costs among patient care staff.³⁵ Another study on the long-term impact of a programme including several patient-handling devices reported a 60% decrease in MSD injury claims and even a steeper drop of 86% in work days lost and 79% in work days on modified duties. The return-on-investment period was less than 15 months.²⁴ Both studies demonstrate that the indirect costs of LBP and other musculoskeletal complaints caused by patient-handling activities may provide a strong impetus for implementation of ergonomic devices.

Our health impact assessment has several limitations that one must bear in mind. First, the Markov chain used in the current analysis was completely defined by the transitions from health to LBP and vice versa which were held constant over time. There are only few longitudinal studies available to evaluate the dynamic course of LBP over a prolonged period of many years. A good consistency was found between incidence, prevalence, incidence, and recurrence used in our disease model and reported in several occupational cohorts. The annual incidence of 25% was consistent with other occupational populations.^{21, 36-37} The high yearly recurrence of low back pain reflects the finding that a history of low back pain is a strong predictor of future episodes.^{19, 36, 38} A study among nurses with 8 years of follow-up concluded that LBP has more a recurrent than a progressive nature.³⁹ The sensitivity analysis showed that the estimated impact of health gains due to the intervention was not sensitive to substantial changes in incidence of LBP and, thus, it is expected that the assumptions on transition probabilities between healthy and incident and recurrent LBP will not have biased the evaluation. However, the simple dichotomy between healthy and having LBP does not take into account severity and aggravation of LBP and it has recently been suggested that mechanical load is related more to the persistence of multi-site pain than its onset.⁴⁰

A second important limitation is the uncertainty in the association between manual lifting of patients and the occurrence of LBP. The majority of studies in table 1 were of cross-sectional design and, as a consequence, causality cannot be determined. The two longitudinal studies showed comparable results and had the highest weights in the meta-analysis with a pooled OR of 2.07. Since most studies did not adjust for awkward back postures and strenuous movements and the number of studies in the meta-analysis was limited, it is difficult to ascertain whether this OR is a good reflection of the true association between manual patient lifting and LBP. A similar remark can be made for the estimated prevalence of exposure of 57% and the MSD injury claim rate in exposed populations. In addition, the review of literature could not provide an exposure-response relationship for increased frequency of patient lifting and

higher occurrence of LBP. Few studies have presented trends in exposure-response, but this evidence was too heterogeneous to be used in a meta-analysis.

This health impact assessment shows that a substantial reduction in the occurrence of LBP and MSD injury claims can only be achieved with good to excellent implementation of lifting devices for patient transfers in healthcare. As stated in several studies, introducing interventions in a dynamic work environment bring about many problems. The fact that only one randomised controlled trial was included in this review underlines the view that a true experimental design in studies concerning the implementation of lifting devices at the workplace is difficult to realise. Workplaces and work organisations are continuously liable to changes that may interfere with the effects of the intervention. It is recommended that intervention studies, whether with observational or experimental design, not only measure the changes in health outcome, but also the changes in mechanical exposure along the pathway of the intervention during a sufficiently long follow-up period.

The modelling of the dynamic pattern of LBP over time demonstrated that large intervention studies with a follow-up period of 3 to 4 years are required in order to demonstrate the effectiveness of lifting devices. This may not be feasible and, thus, a health impact assessment can be used to estimate the potential gains in burden of disease that may go unnoticed in cohort and intervention studies with few years of follow-up. The health impact assessment also presents guidance for design of powerful intervention studies. For example, the pattern of the development of prevalence of LBP presented in figure 1 clearly indicates that the likelihood of demonstrating effectiveness of lifting devices will be substantially higher in newly-hired than in an existing workforce.

In conclusion, this assessment of the impact of lifting devices use on LBP prevalence and injury claims among nurses shows the complexities to demonstrate a noticeable reduction in LBP due to this intervention. Health impact assessment may guide intervention studies as well as implementation of programmes to reduce manually lifting of patients in healthcare.



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Chapter



GENERAL DISCUSSION



In this thesis, a series of studies is presented on the implementation of ergonomic devices in healthcare. A wide range of ergonomic devices have been developed in the past years to reduce the exposure to mechanical load in order to (partly) prevent the occurrence of back complaints. A number of laboratory studies have demonstrated the efficacy of ergonomic devices.¹⁻⁴ However, workplace studies have difficulties showing the effectiveness of ergonomic devices in reducing the occurrence of back complaints.⁵ This requires a better understanding of the underlying factors influencing the effectiveness of these interventions at the workplace.

First, it is important to consider whether mechanical load can be reduced by ergonomic devices use. Furthermore, the compliance to an intervention might influence the effects of the intervention. Therefore, the first objective of this thesis was:

1. To estimate the effect of ergonomic devices on mechanical load and to assess the compliance of use of these devices during patient handling in healthcare.

Second, at the workplace the results of the ergonomic devices will depend not only on the efficacy of the intervention itself, but also on the appropriate implementation of this intervention in the actual work situation.⁶ Many barriers have been identified in intervention studies, at the level of the individual as well as the wider environment.⁷ These factors could influence the compliance of ergonomic devices. For that reason, the second objective of this thesis was:

2. To determine the influence of individual and organisational factors on the appropriate use of ergonomic devices during patient handling in healthcare.

Finally, the difficulties of showing the effectiveness of ergonomic devices could be partly explained by the lack of sufficiently long follow-up periods of intervention studies as well. A reduction in mechanical load during patient handling activities will take some time before a change in the occurrence of low back pain (LBP) can be noted. Hence, these long-term consequences must be assessed in an exposure-disease model that links changes in mechanical load to the occurrence of LBP over time. Therefore, the third objective of this thesis was:

3. To estimate the long-term effects of lifting devices use during transfer activities with patients on the occurrence of LBP among nurses.

In this final chapter, the main findings in the light of the objectives of this thesis will be presented, methodological issues will be discussed, new insights will be considered, and recommendations for practice and future research will be given.



7.1. Main findings

Objective 1: To estimate the effect of ergonomic devices on mechanical load and to assess the compliance of use of these devices during patient handling in healthcare.

In the first part of this thesis, a cross sectional study, performed in 17 nursing homes, gained more insight into the actual use of ergonomic devices during patient handling activities when necessary (according to mobility of the patient) and the effect of these devices on reduction in mechanical load during patient handling activities. The ergonomic devices were used when necessary in 69% of the observed patient handling activities. The use of ergonomic devices and a favourable ratio of nurses per patients at the ward decreased the frequency of forces exerted and the duration of awkward postures during patient handling activities with factors ranging from 1.4 to 22.0. (chapter 2).

Objective 2: To determine the influence of individual and organisational factors on the appropriate use of ergonomic devices during patient handling in healthcare.

In the second part of this thesis, a systematic review regarding barriers and facilitators during the implementation of primary preventive interventions on patient handling in healthcare showed that various individual as well as environmental factors may influence the appropriate implementation and, thus, the effectiveness of these interventions. Five studies identified individual factors, like lack of perceived need and lack of knowledge, and nine studies identified organisational factors, like lack of time, lack of policy of mandatory lift usage, and employee-to-ergonomic device ratio. Environmental factors were far more often reported than individual factors, independent of the type of intervention. Although many barriers have been identified in intervention studies, none of the studies presented a quantitative evaluation of the influence of relevant barriers and facilitators on the effectiveness of the primary preventive interventions (chapter 3).

Following the results of the literature review, a cross-sectional study was conducted in 19 nursing homes and 19 hospitals to identify individual and organisational factors associated with appropriate use of ergonomic devices. Determinants of lifting devices use when necessary during transfer activities with patients were nurses' motivation to use lifting devices, presence of back complaints in the past 12 months, and availability of patient specific protocols with strict guidelines for lifting, with odds ratios of 1.96, 1.77, and 2.49, respectively. Supportive management climate and management support positively influenced the determinants of lifting devices use. No associations were found with the use of other ergonomic devices (chapter 4).

The study in chapter 4 also pointed at the influence of organisational-level measures on nurses' behaviour, comprising both factors in each ward as well as at managerial level of the healthcare institute. Thus, the appropriate implementation of lifting devices requires a

careful process whereby individual behaviour is supported by organisational measures that enable and support the individual to adopt the required behaviour that will contribute to prevention of musculoskeletal complaints. Therefore, the influence of individual and organisational factors on nurses' behaviour, i.e. nurses' motivation to use lifting devices during transfer activities with patients, was evaluated (chapter 5).

Determinants of nurses' behaviour were the availability of sufficient lifting devices on the ward, the availability of patient specific protocols with strict guidelines for lifting, and knowledge of existing workplace guidelines, with odds ratios of 1.92, 2.91, and 5.85, respectively. Subsequently, the interrelationships between organisational factors at different hierarchical levels in the organisation, namely patient's room, ward and institute, were evaluated. Management support, supportive management climate, and the ergocoach as capacity builder (person who enhances access to knowledge and skills by providing training to knowledge and skills users which may lead to positive social outcomes) were associated with the determinants of sustained behaviour among nurses. Management can create important conditions, by providing yearly training of nurses in ergonomic devices use, reserving and spending money to reduce or keep the mechanical load at an acceptable level, providing a sufficient number of ergonomic devices in proportion to mobility of patients, and by supporting maintenance of ergonomic devices on the ward. Figure 1 shows a simplified model of the determinants of lifting devices use, as assessed in chapter 4 and 5.

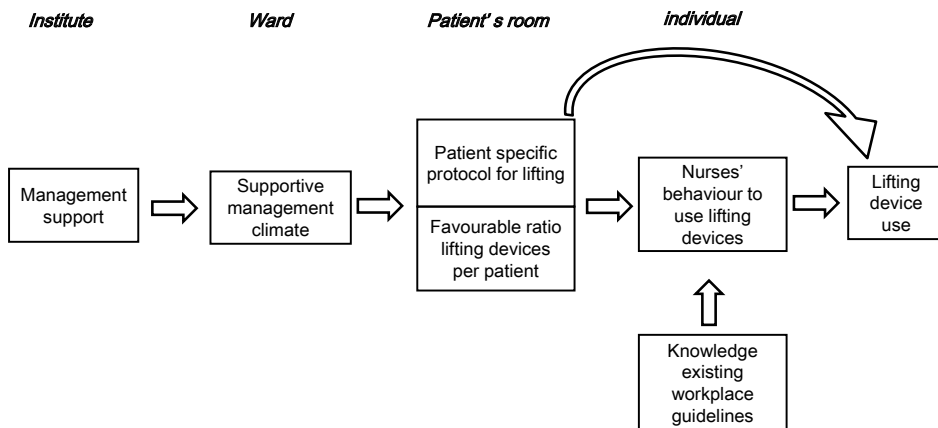


Figure 1 Simplified model of determinants of lifting devices use during transfer activities with patients in healthcare.

In conclusion, determinants of lifting devices use were the motivation of nurses to use lifting devices and the availability of patient specific protocols with strict guidelines for lifting. Determinants of nurses' behaviour, i.e. the motivation of nurses to use lifting devices during transfer activities with patients, were knowledge of existing workplace guidelines, availability of sufficient lifting devices on the ward, and availability of patient specific protocols with

strict guidelines for lifting. Management support and supportive management climate were essential distal factors for sustained behaviour among nurses. Hence, management was able to create important boundary conditions.

Objective 3: To estimate the long-term effects of lifting devices use during transfer activities with patients on the occurrence of low back pain among nurses in healthcare.

In the third part of this thesis, a health impact assessment (HIA) gained more insight in the potential impact of prolonged use of lifting devices during transfer activities with patients on the occurrence of LBP and musculoskeletal disorders (MSD) injury claims among nurses (chapter 6). The baseline scenario with a realistic representation of evidence, available from observational and experimental studies, showed a maximum reduction in the annual prevalence of LBP and MSD injury claims per 100 workers due to lifting devices use of 3.3% and 3.4%, respectively, after 10 years. Complete elimination of manually lifting patients would reduce the annual LBP prevalence with 25.1% and MSD injury claims per 100 workers with 25.9%. The impact of the intervention attenuated over time to a maximum influence after 6 years.

The simulations were not sensitive to expected incidence of LBP in the disease model, however, a change in the magnitude of the association between patient lifting and LBP as well as the prevalence of patient lifting had a considerable influence. The realistic variant of the baseline scenario would require well over 25,000 workers in healthcare with a four-year follow-up to demonstrate effectiveness in an experimental study.

7.2. Methodological issues

For the interpretation of the findings of the studies in this thesis, some methodological issues must be taken into account. Below, the methodological issues concerning study population, study design, and measurement methods of the studies are discussed.

7.2.1. Study population

Chapters 2, 4, and 5 were based upon a study with voluntary participation of nursing homes and hospitals, which may have suffered from selective response. Information on non-responders was not available other than that participating and non-participating healthcare organisations did not differ by urban versus rural areas. Moreover, only nursing homes and hospitals with a structured patient handling programme including the presence of ergocoaches at wards were eligible to participate. It is likely that these healthcare organisations have more structured attention for prevention of high mechanical load. However, in the past few years incentive policies have been enacted in the so-called 'arboconvenanten', a national collective agreement on improvement in working conditions in healthcare branches in 2001-2004.^{8,9} One of the activities encouraged by the 'arboconvenanten' was to have specially trained nurses in ergonomics at

each ward, called ergocoaches. Information from national surveys in 2008 showed that 85% of the nursing homes have employed ergocoaches at wards.¹⁰ Information from national surveys among hospitals in 2005 showed that ergocoaches were present in 56% of the hospitals and had increased from less than 10% in 2001.¹¹ This suggests that the results of this study resemble the situation in Dutch nursing homes and hospitals. Since only Dutch healthcare organisations with a structured patient handling programme were included in this study, some caution is also needed in the generalisability of our results to other countries.

Another source of selection might be the non-response of participants within the nursing homes and hospitals, since it was on voluntary basis. However, the response to participate was considered to be excellent with responses of 100% (nurses and managers of the facilities), 89% (team leader), and 87% (ergocoach). Managers filled out a self-administered questionnaire which was sent to each manager by mail or email and collected personally by the researcher when visiting the organisation. Nurses were observed real-time while performing patient handling activities and afterwards nurses were asked a few short questions. At the start of the observations nurses were invited to participate. None of the nurses who were invited to contribute to the study refused to participate. In particular circumstances, like critical situations with patients, nurses were not asked to participate by the researcher. This counted for approximately 10-15% of possible participation. Due to the high response, it is not likely that selective non-response has influenced our findings.

7.2.2. Study design

The studies in chapters 4 and 5 had a cross-sectional design, i.e. the measurement of determinants and outcome took place at the same moment in time. Therefore, it was not possible to determine the direction of associations between determinant and outcome. Randomised controlled trials (RCT) are considered to be the most rigorous way of determining whether a cause-effect relation exists between determinants and outcome.¹² Although RCTs are powerful tools, their use is limited by ethical and practical concerns.¹³ In this specific context a RCT is not appropriate, since it is almost not feasible, in our experience, to ask organisations to invest substantially in ergonomic devices or manpower (i.e. ergocoaches), based on random allocation by the research team. A second argument against an experimental study is that since the introduction of ergocoaches at wards was part of the collective agreement 'arbo-convenant' within sectors of healthcare, it was no longer possible to randomly allocate the introduction of ergocoaches at wards in healthcare organisations.^{10, 14, 15} However, due to the large number of healthcare organisations participating in this study (38 organisations), the cross-sectional design is actually a powerful tool in this study.

Another methodological issue that cannot be tackled with a cross-sectional design is the so-called lag between changes in the determinants and increased or decreased occurrence of MSD. The results from chapter 4 and 5 showed that several individual and organisational factors were associated with lifting devices use during transfer activities with patients and



nurses' behaviour to these lifting devices. However, these studies gave no insight into the time window of the influence of these determinants. The individual and organisational factors may have an immediate or delayed influence on the transition from not using lifting devices to lifting devices use. It is, for example, not known how long it took before nurses were motivated to use lifting devices, how long lifting devices were already available at wards, and how long nurses were trained in ergonomic devices use. Interrupted time-series with repeated measurements over longer periods can give more insight into the time-dynamics of the influence of individual and organisational factors on lifting devices use during transfer activities with patients.¹⁶ However, a cross sectional study is efficient for exploring and generating hypotheses for further research. Studies with more robust designs are needed to corroborate the findings from the cross-sectional study and to be able to draw firmer conclusions.

7.2.3. Measurement methods

The majority of the information in this thesis was self-reported by participants, i.e. self-reported determinants at the level of the organisation (management support and supportive management climate), the ward (convenience and easily accessibility of ergonomic devices and activities of the ergocoach), and the individual nurse (musculoskeletal complaints, ability and planned behaviour with regard to ergonomic devices use). Self-reported measures have the advantage that they are relatively easy to obtain, applicable to a wide range of working situations, and appropriate for surveying large numbers of subjects at comparatively low cost.¹⁷ On the other hand, self-reported measures have the disadvantage that reporting bias may occur. Respondents may be susceptible to social norms and tend to provide answers to questions towards perceived socially desirable standards. Thus, the proportion of nurses motivated to use lifting devices might be overestimated.

Real-time observations were used to estimate mechanical load, i.e. trunk postures and forces exerted, at the workplace during patient handling activities (chapter 2). For assessing exposure to forces exerted direct measurements are preferred.¹⁸ Direct measurements, such as electromyography (EMG), can provide highly accurate data on a range of exposure variables over prolonged periods of time. However, EMG cannot be rendered into forces exerted and trunk postures, only in applied muscle forces. The advantage of real-time observations is the ability to collect detailed quantitative information on several aspect of mechanical load simultaneously. Another advantage of this approach is its practical use in a wide range of workplaces and work situations, whereas direct measurements may be difficult because of the disruption caused.¹⁷ The assessment of trunk postures through observations will have resulted in some inter- and intra-observer variability, which contributes to the overall variance observed.¹⁹ In our study the large number of observations were sufficient to provide meaningful estimates of important exposure determinants. Moreover, adjustment for the observers did not influence the estimates of exposure determinants. The review of Takala et al. showed that different observers will report reasonably similar results when they have

adopted similar concepts and skills through sufficient training.¹⁹ The forces exerted in the studies in this thesis were assessed according to a strict protocol. For each manipulation during a patient handling activity studies were identified that presented actual measurements of the forces applied during corresponding patient handling situations, as described in chapter 2. The average of the force measurements in each activity was used to classify that activity within the categories <100N, 100-230N, and > 230N. For the assessment of forces exerted a crude classification of forces was chosen intentionally, with the advantage of less misclassification. The review of Stock et al. showed that the reproducibility of materials handling was fair to excellent with better results using a crude classification of forces instead of a more detailed classification.²⁰

Ergonomic devices use during patient handling activities was assessed through real-time observations as well (chapters 2, 4, and 5). The presence of researchers at the ward might have influenced the devices use among nurses. Nurses were, however, not aware of the fact that the actual use of ergonomic devices was assessed during the real-time observations, because the nurses were only told that mechanical load during patient handling activities was assessed.

7.2.4. *Modelling approach*

The long term consequences of lifting devices use on the occurrence of LBP was assessed by means of a health impact assessment (HIA) (chapter 6). The HIA simulated two hypothetical cohorts of nurses. Both cohorts were followed up for a period of 10 years. The impact of lifting devices in healthcare on the annual prevalence of LBP and annual MSD injury claims were evaluated in different scenarios.

A HIA is defined as a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, programme or project on the health of a population and the distribution of those effects within the population.²¹ An important limitation is that it is confined to the small number of determinants for which there is a well-defined exposure–response relationship. In reality, most interventions are more complex and involve multiple determinants, multiple health outcomes, and various non-quantified costs and benefits.²² Little is known about the validity and reliability in HIA.²³ We would tentatively define the validity of HIA studies as the degree to which the predicted health effects are confirmed by empirical research. Thus, validation against longitudinal studies with substantial follow-up periods of at least three to four years is required to evaluate whether the prediction of the HIA performed is reasonable.

A HIA has an important role in producing estimates for the health impacts of those determinants where there is a sufficient base of research to quantify relationships between population exposure and health, and to predict the effects of policies on population exposure.²² It can be a powerful methodology to evaluate the impact of different intervention strategies,



thereby helping to provide the evidence base necessary to gain widespread stakeholder support for implementing health policies.²³

7.3. New insights

Implementation process as an integral part of intervention

Various barriers for the appropriate implementation of ergonomics interventions in healthcare have been mentioned in intervention studies.⁷ Barriers appear at different levels within an organisation, from the individual until the management level. This phenomenon is not limited to the healthcare sector, as was illustrated in a recent review on implementation of participatory ergonomic interventions in workplaces in over ten different sectors/industries.²⁶

Although many barriers have been identified in the literature, quantitative evaluation of the influence of these barriers on the effectiveness of the interventions is lacking.^{7, 26} The drawback of this qualitative approach is that the effectiveness of an intervention is separated from the implementation process. There is a clear need for a process evaluation that presents insight in the impact of the barriers and facilitators on the outcome of an intervention.²⁷ In order to establish this, the process evaluation should be considered as an integral part of the intervention. In addition, a process evaluation can be used to assess whether changes in outcomes arise from the intervention with plausible pathways linking intervention and outcome(s).²⁸

Theories on implementation in healthcare confirm the importance of identifying obstacles to change existing work practices and evaluating their influence on the effectiveness of an intervention.²⁹ This will give more insight in the reasons for failure of the effectiveness of interventions. Moreover, intervention studies can utilize assessed barriers and facilitators from other intervention studies to optimise the implementation of their intervention.

Integrating working conditions and quality of care with lifting devices

The compliance of lifting devices can be stimulated by a combination of improvements in working conditions and quality of care. A good working environment culminates in quality products.³⁰ This thesis showed that a better compliance to use of lifting devices was influenced by a chain of factors; starting with nurses' behaviour and strict lifting guidance, supported by encouraging safe working conditions through sufficient lifting devices on the ward. Recent studies corroborate the importance of stimulating working conditions.^{31, 32} The chain also includes factors at higher hierarchical levels in the organisation, such as management support and a supportive management climate. These organisational factors were less important than facilities in the direct environment of nurses, however, management can create important conditions.³⁰ Organisational factors at different levels in a healthcare institute, such as patient's room, ward, and organisation, are hierarchically linked and it is, therefore, important to consider how these factors at different levels interact.³³ It is expected

that organisational factors that influence quality of healthcare are also important factors for the appropriate implementation of ergonomic interventions at a workplace.³³

Outcome measures in intervention studies

In the evaluation of ergonomic interventions, it is crucial to include proper outcome measures. Ergonomic interventions, such as lifting devices, decrease mechanical load during patient handling activities. The main impact of a reduction in mechanical load at work may be on the persistence of pain rather than the onset of new symptoms.³⁵ Mechanical load also has a strong impact on associated sickness absence and work related disability.³⁶ Frequent lifting has been identified as a determinant in the transition from acute to chronic pain, whereby mechanical load aggravates pain, resulting in increased functional limitations.³⁷ It is possible that the workers with an injury are able to return to work earlier when the presence of assistive equipment has reduced some of the most strenuous physical demands of work.³⁸

Therefore, outcome measures, such as MSD injury claims or sickness absence, may be more suitable in the evaluation of ergonomic interventions than the occurrence of LBP. Other studies have suggested as well that ergonomic interventions will have a greater impact on lost work days than on occurrence of episodes of LBP.^{34, 38} The HIA in chapter 6 supported this, since the long-term consequences of lifting devices use was larger on MSD injuries claims than on the annual prevalence of LBP.

Health Impact Assessment as guidance for improving musculoskeletal health

A health impact assessment (HIA) is a valuable technique to assess the potential effects of an intervention. A reduction in mechanical load during transfer activities with patients due to lifting devices use will take some time before a change in the occurrence of LBP can be noted.³⁶ In order to demonstrate an impact of lifting devices on the occurrence of LBP, it was estimated that over 10,000 workers need to be included in an experimental study with three to four years follow-up. This will seldom be feasible and, thus, a HIA can be used to estimate the potential gains in burden of disease that may go unnoticed in cohort and intervention studies with few years of follow.

The HIA in this thesis provides quantitative insight into how ergonomic interventions might lead to substantial differences in the occurrence of new cases of LBP and overall change in disease burden and the rate with which changes occur.³⁹ This information can assist policy makers in their choice of interventions and strategies and gives guidance for achievable reductions in disease burden.³⁹ It can also benefit researchers in designing powerful cohort and intervention studies and implementation strategies.

Health impact assessment (HIA) are valuable tools to evaluate policy and programmes in a wide range of areas⁴⁰. Examples of HIAs are the potential impacts of a proposed food-procurement policy to reduce sodium consumption, air quality and health impact of PM10



and EC in the city of Rotterdam, and the health risks and benefits of mode shifts from car to cycling and public transport in the metropolitan area of Barcelona, Spain.⁴¹⁻⁴³

In conclusion, a HIA is valuable as guidance in designing intervention studies and implementation strategies in order to improve musculoskeletal health.

The workplace as natural experiment

Differences among workplaces can be regarded as natural experiments in which the experimental conditions are determined by the differences between organisations. The randomised controlled trials (RCTs) are widely viewed as the 'gold standard' for estimating the causal effects of interventions on outcomes in a specific population.¹² However, non-randomised evaluations are essential to inform public health decision-making where there are clear barriers to conduct RCTs.^{28, 44} Non-randomised designs might provide adequate evidence when confounders are well-understood, measured and controlled, when there is evidence for causal pathways linking intervention and outcomes and/or against other pathways explaining outcomes, and effect sizes are large.²⁸ Careful statistical analysis can help reduce bias by confounding in estimating intervention effects.⁴⁴

7.4. Recommendations for practice

Providing sufficient material and care personnel

The results in part 1 of this thesis showed that the use of ergonomic devices during patient handling activities strongly reduced the exposure to forces exerted and awkward working postures, especially the use of lifting devices during transfer activities with patients and the use of an electric adjustable bed during personal care of patients. It is, therefore, recommended to provide a sufficient number of ergonomic devices at each ward of healthcare organisations.

Moreover, a favourable number of nurses in proportion to the patients at the ward resulted in a reduction in mechanical load as well. Thus, it is advised to provide sufficient care personnel for the required patient handling activities.

Eliminate manual lifting of patients in healthcare

The results of part 3 of this thesis showed that a substantial reduction in the occurrence of LBP among nurses can only be achieved with good to excellent implementation of lifting devices for patient transfers in healthcare. Manually lifting patients should be entirely eliminated. It is recommended that the management of healthcare organisations enact a strict policy with regard to avoiding manual lifting of patients.

Stimulating appropriate use of ergonomic devices

The use of ergonomic devices should be stimulated at different levels within the healthcare organisation, as shown in part 2. Healthcare organisations should start by stimulating a sustained behaviour among nurses to use ergonomic devices, supported by strict patient specific guidelines for patient handling activities. This will require a sufficient provision of equipment at each ward and education and training in existing procedures. Finally, management should create the essential conditions by ensuring that nurses are being trained in ergonomic devices use each year, money is reserved to reduce or keep the mechanical load at an acceptable level, a sufficient number of ergonomic devices is provided in proportion to the mobility of the patients at the ward, and that ergonomic devices are being maintained.

7.5. Recommendations for future research

Process evaluation as an integral part of the intervention study

The process evaluation should be adopted as an integral part of the intervention study. Barriers and facilitators in the implementation of ergonomic interventions can influence the outcome of an intervention. The results of this thesis show that individual and organisational factors have a considerable influence whether effective interventions will indeed contribute to a reduction in mechanical load (chapters 4 and 5). The influence of barriers and facilitators on the implementation process and effectiveness of an intervention should, therefore, be assessed, in order to gain more insight in the causes for failure of effectiveness of an intervention at the workplace.

Organisational and individual factors in the evaluation of appropriate implementation

Barriers and facilitators of appropriate implementation of interventions are often mentioned all at once, while the approach in this thesis, as depicted in figure 1, shows that it is important to distinguish individual and organisational factors at different levels in the evaluation of appropriate implementation. Individual behaviour cannot be assessed without taking into account the influence of the organisational factors. Since there is a hierarchical structure (rooms within ward and wards within the institute), multi-level analyses should be considered to understand how variables at different levels interact.

There is an apparent lack of studies that quantify the effect of barriers and facilitators on implementation and effectiveness of interventions. There is a clear need for research on the influence of individual and organisational factors on the observed effects of interventions.

Assess changes in mechanical exposure along the pathway of the intervention

Part 3 of this thesis showed that the impact of lifting devices on the occurrence of LBP strongly depends on the proportion of LBP that is attributable to manual lifting of patients. There is considerable debate in the scientific literature the contribution of manually lifting patients



to the occurrence of LBP in healthcare. It is, therefore, recommended that intervention studies not only measure the changes in health outcome, but also the underlying changes in mechanical exposure in order to present additional evidence on the importance of manually lifting patients to LBP among nurses.

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SUMMARY

This thesis aimed to contribute to the understanding of the effect of ergonomic interventions on musculoskeletal health and the role of individual and organisational factors on the appropriate implementation of ergonomic interventions. The primary objectives of this thesis were (1) to estimate the effect of ergonomic devices on the exposure to mechanical load and to assess the compliance to use of these devices during patient handling in healthcare, (2) to determine the influence of individual and organisational factors on the appropriate use of ergonomic devices during patient handling activities in healthcare, and (3) to estimate the long-term effects of lifting devices use during transfer activities with patients on the occurrence of low back pain among nurses. The first objective was addressed in chapter 2, the second objective in chapters 3 to 5, and the third objective in chapter 6.

Chapter 2 described a cross-sectional study in 17 nursing homes on the required and actual use of ergonomic devices during patient handling activities and the effects of its use on reduction in mechanical load during patient handling activities. Ergonomic devices were used when necessary in 69% of 735 patient handling activities observed. The use of ergonomic devices and a favourable ratio of nurses per patients decreased the frequency of forces exerted and the duration of awkward postures with factors ranging from 1.4 to 22.0. The use of ergonomic devices was high and this use substantially reduced forceful movements and awkward postures and, thus, will most likely contribute to the prevention of low back pain among nurses.

Chapter 3 presented a systematic review aimed at identifying barriers and facilitators during implementation of primary preventive interventions on patient handling in healthcare and their influence on the effectiveness of these interventions. In total, 16 individual and 45 environmental barriers and facilitators were identified in 19 studies. The most important environmental categories were 'convenience and easily accessible' (56%), 'supportive management climate' (18%), and 'patient-related factors' (11%). An important individual category was motivation (63%). None of the studies quantified their impact on effectiveness, nor on compliance and adherence to the intervention.

Chapter 4 evaluated the influence of individual and organisational determinants on ergonomic devices use during patient handling activities in a cross-sectional study in 19 nursing homes and 19 hospitals. Determinants of lifting devices use were nurses' motivation (OR=1.96), presence of back complaints in the past 12 months (OR=1.77), and the availability of patient specific protocols with strict guidelines for lifting (OR=2.49). The organisational factors convenience and easily accessible, management support, and supportive manage-



ment climate were associated with these determinants. No associations were found with other ergonomic devices.

Chapter 5 evaluated the influence of individual and organisational factors on nurses' behaviour to use lifting devices during transfer activities with patients in the same study population as chapter 4. The determinants of nurses' behaviour, i.e. nurses' motivation to use lifting devices during transfer activities with patients, were availability of sufficient lifting devices on the ward (OR=1.92), availability of patient specific protocols with strict guidelines for lifting (OR=2.91), and knowledge of existing workplace guidelines (OR=5.85). At higher hierarchical levels in the organisation, management support and a supportive management climate were associated with these factors supporting sustained behaviour among nurses.

Chapter 6 presented a Markov decision analysis model for a health impact assessment of patient lifting devices use in healthcare. The baseline scenario with a realistic representation of evidence, available from observational and experimental studies, showed a maximum reduction in the annual low back pain prevalence from 41.9% to 40.5% after 10 years. Complete elimination of manually lifting patients would reduce the low back pain prevalence from 41.9% to 31.4%. The simulations were not sensitive to expected incidence of low back pain, but the magnitude of the association between patient lifting and low back pain as well as the prevalence of patient lifting had a considerable influence. The realistic variant of the baseline scenario would require well over 25,000 workers in healthcare to demonstrate effectiveness in an experimental intervention study.

Chapter 7, the general discussion, started with presenting the main findings in the light of the study objectives, followed by methodological issues that should be acknowledged when interpreting the findings. New insights in the effect of ergonomic devices on the exposure to mechanical load and the occurrence of low back pain and the influence of individual and organizational factors on the actual use of lifting devices were described. Finally, recommendations for practice and future research were presented.

SAMENVATTING

In dit proefschrift onderzoeken we het effect van ergonomische interventies op klachten van het houdings- en bewegingsapparaat en de rol van individuele en organisatorische factoren op de implementatie van ergonomische interventies. De volgende doelstellingen staan centraal in dit proefschrift: (1) Het bepalen van de effecten van ergonomische hulpmiddelen op de blootstelling aan fysieke belasting en het gebruik van deze hulpmiddelen tijdens patient gebonden handelingen in de gezondheidszorg, (2) het bepalen van de invloed van individuele en organisatorische factoren op het adequaat gebruik van ergonomische hulpmiddelen tijdens patient gebonden handelingen in de gezondheidszorg en (3) het bepalen van het lange termijn effect van tillift gebruik tijdens transfer activiteiten met patienten op het vóórkomen van lage rugpijn. De eerste doelstelling wordt behandeld in hoofdstuk 2, de tweede doelstelling wordt behandeld in hoofdstukken 3, 4 en 5 en de derde doelstelling wordt behandeld in hoofdstuk 6.

Hoofdstuk 2 beschrijft een dwarsdoorsnede studie in 17 verpleeg- en verzorgingshuizen naar het noodzakelijk en werkelijk gebruik van ergonomische hulpmiddelen tijdens patient gebonden handelingen en het effect van deze ergonomische hulpmiddelen op de reductie in fysieke belasting tijdens patient gebonden handelingen. In 69% van de 735 geobserveerde patient gebonden handelingen werden ergonomische hulpmiddelen waar noodzakelijk gebruikt. Het gebruik van ergonomische hulpmiddelen en een gunstige ratio van verzorgenden/verpleegkundigen per patient reduceerden de frequentie uitgeoefende krachten en de duur waarin in ongunstige rughoudingen werd gewerkt met factoren variërend tussen 1,4 en 22,0. Het gebruik van ergonomische hulpmiddelen zal hoogstwaarschijnlijk een bijdrage leveren aan de preventie van lage rugklachten bij verzorgenden en verpleegkundigen omdat het gebruik van de ergonomische hulpmiddelen hoog was en de ergonomische hulpmiddelen de krachtige bewegingen en ongunstige rughoudingen substantieel reduceerden.

Hoofdstuk 3 beschrijft een systematische review naar belemmerende en bevorderende factoren tijdens de implementatie van primaire preventieve interventies met betrekking tot patient gebonden handelingen in de gezondheidszorg en de invloed van deze factoren op de effectiviteit van deze interventies. In totaal werden 16 individuele en 45 organisatorische belemmerende en bevorderende factoren geïdentificeerd in 19 studies. De belangrijkste organisatorische factoren waren 'goede toegankelijkheid' (56%), 'stimulerend management klimaat' (18%) en patientgerelateerde factoren (11%). Een belangrijke individuele factor was motivatie (63%). Geen enkele studie heeft het effect van de factoren op zowel de effectiviteit, als op de naleving van en de toewijding aan de interventie gekwantificeerd.



Hoofdstuk 4 evalueert de invloed van individuele en organisatorische determinanten van het gebruik van ergonomische hulpmiddelen indien noodzakelijk tijdens patient gebonden handelingen in een dwarsdoorsnede onderzoek in 19 verpleeg- en verzorgingshuizen en 19 ziekenhuizen. Determinanten van tillift gebruik waren de motivatie van verzorgenden/verpleegkundigen ($OR=1,96$), de aanwezigheid van rugklachten in de afgelopen 12 maanden ($OR=1,77$) en de aanwezigheid van patientgebonden protocollen voor tillen ($OR=2,49$). De organisatorische factoren goede toegankelijkheid, ondersteuning vanuit management en een stimulerend management klimaat waren geassocieerd met deze determinanten. Er werden geen associaties gevonden bij andere ergonomische hulpmiddelen.

Hoofdstuk 5 evalueert de invloed van individuele en organisatorische factoren op het gedrag van verzorgenden/verpleegkundigen om tilliften te gebruiken tijdens transfer activiteiten met patienten in dezelfde studiepopulatie als in hoofdstuk 4. Determinanten van het gedrag van verzorgenden/verpleegkundigen, d.w.z. de motivatie van hen om tilliften te gebruiken tijdens transfer activiteiten met patienten, waren de aanwezigheid van voldoende tilliften op de afdeling ($OR=1,92$), de aanwezigheid van patientgebonden protocollen voor tillen ($OR=2,91$) en kennis van aanwezige praktijkrichtlijnen ($OR=5,85$). Ondersteuning vanuit management en een stimulerend management-klimaat waren geassocieerd met deze factoren die behoud van gedrag onder verzorgende/verpleegkundigen stimuleren.

Hoofdstuk 6 presenteert een Markov model voor een gezondheidsanalyse van tillift gebruik in de gezondheidszorg. De baseline scenario met een realistische representatie van het bewijs, beschikbaar van observationele en experimentele studies, lieten een maximale reductie zien van de jaarprevalentie van lage rugklachten van 41,9% naar 40,5% na 10 jaar. Volledige eliminatie van handmatig tillen van patienten zou de jaarprevalentie van lage rugklachten verlagen van 41,9% naar 31,4%. De modelsimulaties waren niet gevoelig voor de verwachte incidentie van lage rugklachten, maar de simulaties werden wel aanzienlijk beïnvloed door zowel de associatie tussen het tillen van patienten en lage rugklachten als prevalentie van handmatig tillen van patienten. Voor de realistische variant van de baseline scenario zouden meer dan 25.000 medewerkers in de gezondheidszorg nodig zijn om de effectiviteit in een experimenteel interventie onderzoek aan te tonen.

Hoofdstuk 7, de algemene discussie, begint met het presenteren van de belangrijkste bevindingen in het licht van de onderzoeksvragen, gevolgd door methodologische beperkingen die van belang zijn bij de interpretatie van de bevindingen. Nieuwe inzichten in het effect van ergonomische hulpmiddelen op de blootstelling aan fysieke belasting en het voorkomen van lage rugpijn en de invloed van individuele en organisatorische factoren op het werkelijk gebruik van tilliften worden beschreven. Hoofdstuk 7 eindigt met aanbevelingen voor praktijk en toekomstig onderzoek.

DANKWOORD

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ABOUT THE AUTHOR

Elin van Kats-Koppelaar was born on August 12 1975, in Rotterdam, the Netherlands. After graduating from secondary school at the Montessori Lyceum in Rotterdam in 1994, she started studying physical therapy Cesar at the Utrecht University of Applied Sciences in Utrecht. She received her Bachelor degree in 1999 and started working as a therapist in several practices in the Netherlands. In 2000, she started a Master of Science in Human Movement Sciences at the VU University in Amsterdam. In 2003 she obtained her Master of Science degree with a major in Ergonomics. In 2004 she started as a scientific employee at the Netherlands Expert Center for Workrelated Musculoskeletal Disorders, Erasmus MC, University Medical Center Rotterdam for four months. Subsequently, she worked as a scientific researcher for 2 years at the Department of Rheumatology, Erasmus MC, University Medical Center Rotterdam. In 2006 she started with the PhD project resulting in this thesis at the Department of Public Health of the Erasmus MC in Rotterdam. Currently, she is working as a scientific researcher/teacher at the Expert Center of Health Innovation, Rotterdam University of Applied Sciences. Elin is married to Frank van Kats and they have two daughters, Liva (2008) and Yente (2011).

Elin van Kats-Koppelaar is geboren op 12 augustus 1975 te Rotterdam, Nederland. In 1994 behaalde ze haar VWO-diploma aan het Montessori Lyceum te Rotterdam. Vervolgens startte zij met de opleiding oefentherapie Cesar aan de hogeschool Utrecht in Utrecht. Ze behaalde haar Bachelor diploma in 1999 en ging werken als oefentherapeut Cesar in verschillende praktijken in Nederland. In 2000 startte zij met de studie Bewegingswetenschappen aan de Vrije Universiteit te Amsterdam. In 2003 studeerde zij af met als afstudeerrichting Ergonomie. Na haar afstuderen heeft zij vier maanden als wetenschappelijk medewerker gewerkt bij het Nederlands Kenniscentrum Arbeid en Klachten Bewegingsapparaat. Daarna was ze 2 jaar werkzaam als wetenschappelijk onderzoeker op de afdeling Reumatologie van het Erasmus MC in Rotterdam. Vanaf 2006 was zij als wetenschappelijk onderzoeker verbonden aan de afdeling Maatschappelijke Gezondheidszorg van het Erasmus MC in Rotterdam en voerde het promotieonderzoek uit dat resulteerde in dit proefschrift. Momenteel is zij werkzaam als wetenschappelijk onderzoeker/docent bij het kenniscentrum Zorginnovatie binnen de Hogeschool Rotterdam. Elin is getrouwd met Frank van Kats en samen hebben zij twee dochters, Liva (2008) en Yente (2011).



LIST OF PUBLICATIONS

2012

Koppelaar E, Knibbe JJ, Miedema HS, Burdorf A. The influence of ergonomic devices on mechanical load during patient handling activities in nursing homes. *Ann Occup Hyg* 2012;56:708-18.

Koppelaar E, Knibbe JJ, Miedema HS, Burdorf A. The influence of individual and organisational factors on nurses' behaviour to use lifting devices in healthcare. *Appl Ergon* 2012; epub ahead of print.

2011

Koppelaar E, Knibbe JJ, Miedema HS, Burdorf A. Individual and organisational determinants of use of ergonomic devices in healthcare. *Occup Environ Med* 2011;68:659-65.

2009

Koppelaar E, Knibbe JJ, Miedema HS, Burdorf A. Determinants of implementation of primary preventive interventions on patient handling in healthcare: a systematic review. *Occup Environ Med* 2009;66:353-60.

2005

Koppelaar E, Wells R. Comparison of Measurement Methods for Quantifying Hand Force. *Ergonomics* 2005;48:982-1007.

Nauta N, Koppelaar E. Verwijzing door bedrijfsartsen bij lage-rugklachten. Gebeurt dat en naar wie? *Nederlands Tijdschrift voor Ergotherapie* 2005;4:168-70.

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2004

Koppelaar E, Kuiper JI. Effectiviteit van behandelingen bij het Carpaal Tunnel Syndroom. *Nederlands Tijdschrift voor Oefentherapie Mensendieck* 2004;1:4-5.

Submitted

Burdorf A, Koppelaar E, Evanoff B. Assessment of the impact of lifting device use on the occurrence of low back pain among nurses.



PHD PORTFOLIO

Summary of PhD training and teaching activities

PhD student: Elin Koppelaar

Erasmus MC, Department of Public Health

PhD period: 2006-2012

Promotor: Prof.dr.ir. A. Burdorf

	Year	Workload (ECTS)
1. PhD training		
Research skills		
Erasmus Summer programme, Erasmus MC, Rotterdam		
Introduction to data analysis	2008	0.9 ECTS
Regression analysis	2008	1.9 ECTS
Scientific Presentations		
Oral presentation at International Conference Healthcare systems Ergonomics and Patient Safety, Strasbourg, France	2008	1.5 ECTS
Research meetings, Department of Public Health, Rotterdam	2009	1.5 ECTS
Oral presentation at 7 th International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders PREMUS, Angers, France	2010	1.5 ECTS
International conferences		
International Conference Healthcare systems Ergonomics and Patient Safety, Strasbourg, France	2008	0.9 ECTS
7 th International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders PREMUS, Angers, France	2010	1 ECTS
Seminars		
Attending seminars of the Department of Public Health (approximately 30 seminars during 4 years)	2006-2010	5 ECTS
Attending and organizing meetings of the supervisor group of this study	2006-2010	1.8 ECTS



2. Teaching activities

Supervising bachelor thesis	2007-2010	6 ECTS
Supervising Master thesis	2008	6 ECTS
Supervising writing a review by medical students 2 nd year, Erasmus MC, Rotterdam	2009-2010	2 ECTS
