Applied Ergonomics 65 (2017) 209–222

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Review article

Validity and reliability of the HEMPA method for patient handling assessment

A. Villarroya [a, *], P. Arezes [b], S. Díaz de Freijo [c], F. Fraga [c]

[a] Lucus Augusti Hospital, Servizo Galego de Saúde, Rúa Dr. Ulises Romero, nº 1, 27004 Lugo, Spain
[b] Research Centers for Industrial and Technology Management & Algoritmi, School of Engineering, University of Minho, 4800-058 Guimarães, Portugal
[c] Department of Applied Physics, Faculty of Science, University of Santiago de Compostela, Lugo, Spain

ARTICLE INFO

Article history:
Received 12 March 2016
Received in revised form
3 May 2017
Accepted 24 June 2017

Keywords:
Risk assessment
Patient handling
Hospitals
Ergonomics
HEMPA

ABSTRACT

Specific methods currently exist to assess occupational hazards resulting from patient handling in the healthcare sector, according to ISO/TR 12296. They are all similar in nature, but with a different analysis perspective; for that reason a comparison of the most relevant methods was performed in a previous research. As a result, a basis of a new tool that integrates the complementary aspects of those methods was proposed. To verify the validity and reliability of that method, a study within a hospital setting was carried out in five medical and surgical units of a public health institution. Based on the obtained results, the analysed method (called HEMPA) proved to be valid and reliable. Also, this method reflects a positive correlation between risk and damage and correctly quantifies risks regarding patient's dependence.

© 2017 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author.
E-mail addresses: alberto.villarroya.lopez@sergas.es (A. Villarroya), parezes@dps.uminho.pt (P. Arezes), santifreijo@mundo-r.com (S. Díaz de Freijo), Francisco.Fraga@usc.es (F. Fraga).

http://dx.doi.org/10.1016/j.apergo.2017.06.018
0003-6870/© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

It is a frequently reported fact in the scientific literature that patient handling is one of the main risk factors among caregivers (Engkvist et al., 1998; Goldman et al., 2000), particularly in terms of back pain (Hoogendoorn, 2002; Smedley and Egger, 1995) and musculoskeletal disorders development (Larese and Fiorito, 1994; Leigthon and Reilly, 1995; Ando et al., 2000). Caregivers are exposed to various risk factors, such as lifting and transferring patients, pushing and pulling heavy equipment or working in awkward postures (National Research Council and Institute of Medicine, 2001). Musculoskeletal disorders are therefore of particular relevance, as workers who experience pain or fatigue are more likely to suffer accidents. In fact, some workers who suffer disabling injuries have abandoned the profession (Stubbs et al., 1986). Moreover, workplaces with a high incidence of these risks support high losses, with increased costs and staff turnover (OSHA, 2009). Regarding musculoskeletal disorders due to biomechanical overload, it was found that there is prevalence of back pain among nurses, particularly in the lumbar region, mainly because of the great variability of patient handling, the nature of liftings and the lack of training about the correct execution of movements (Bordini et al., 1999). In addition, patient handling has been increasingly recognized as a high risk activity, so the task could be redesigned to reduce risk exposure, implementing practical handling programs to improve the patient safety (De Castro et al., 2006).

Another study also suggests that injuries severity can be reduced substantially with a proper ergonomic intervention to reduce the physical stress and the risk of injury of caregivers (Garag and Owen, 1994).

Regarding the above, it is known that there have been major advances studying working conditions, aiming at accurately assess risks. Among these advances, there are certain methods to evaluate the patient handling technique (Kjellberg et al., 2000) or specific methods as MAPO, DINO, Dortmund Approach, Care Thermomether or PTAI that proved to be valid, as reported in previous studies (Battevi et al., 2006; Johnsson et al., 2004; Jager et al., 2010; Steer and Knibbe, 2008; Karhula et al., 2009). Additionally, it has been shown that multifactorial interventions are most appropriate for reducing musculoskeletal injury rates (De Troyer, 2015). In this sense, the European Panel on Patient Handling Ergonomics (EPPHE) in its international technical report recommended a comprehensive strategy, based on risk analysis associated with patient handling and taking into account all factors that could affect that task in the most complete way.

For that reason, it seems clear that prevention of musculoskeletal disorders resulting from patient handling requires proper assessment tools to provide the most balanced approach possible, according to a group of variables that influence this handling. Thus, due to the lack of a comprehensive measurement tool, the TROPHI method (proposed by Fray and Hignett, 2013) aims to evaluate both complex and multifactorial interventions during patient handling. Other tools combine several strategies integrated into a single generic program, to improve worker's occupational health (Hignett and Fray, 2010). Also it has been proposed a method to compare all patient handling tasks, based on the examination of twelve variables, setting a single indicator to evaluate all the interventions (Fray and Hignett, 2010).

Keeping that orientation, a study comparing five of the most relevant assessment methods of patient handling -MAPO, DINO, PTAI, Care Thermometer and Dortmund Approach, all of them included in ISO/TR 12296:2012 standard-was developed (Villarroya et al., 2016). With this purpose, the most valued items were integrated into a single method called HEMPA (“Herramienta de evaluación de movilización de pacientes”, or “Patient handling assessment tool”) to obtain an overall quantitative assessment.

HEMPA intends to be a comprehensive method, regardless the weaknesses or limitations of the previously compared methods, which also pursue the same purpose, that is, to evaluate patient handling risk, although they follow different pathways. This tool aims to provide a quantitative final result to determine whether the risk of suffering musculoskeletal disorders during patients transfer is acceptable, moderate or unacceptable for the caregiver, regarding the patient's degree of dependence. Therefore, the aim of the current study is to establish the validity and reliability of the HEMPA method to assess patient handling risks, similarly to other previously published studies (Radovanovic and Alexandre, 2004; Battevi et al., 1999, 2006). This paper also includes a brief discussion of the considered items, the way scores are assigned as well as the quantification of the resulting risk levels.

2. Materials and methods

2.1. 2.1 HEMPA items

HEMPA is an assessment tool based in observation of workplaces where patient handling takes place regularly. The method compiles the items that were considered to be relevant in the previously mentioned comparison (Villarroya et al., 2016). These items are major components of a typical healthcare scenario, mostly cited in ISO/TR 12296, and are taken from the valuation criteria adopted by the different methods analysed:

a) Dependency level.
b) Environmental conditions.
c) Workspaces.
d) Minor aids.
e) Major aids.
f) Transfer execution and postural analysis.
g) Handling outcome.

h) Work organization.
i) Training.
j) Risk perception.

2.2. Items scoring

The score for each item is based on the frequency with which each item was repeated in the comparative study among the five reference methods, namely MAPO, DINO, PTAI, Care Thermometer and Dortmund Approach.

The reason underlying the selection of those methods was the different range of aspects valued by each of them. This allows to cover a wide range of study variables, including the work organization (MAPO), patient handling technique (DINO), the physical load caused by transferring patients (PTAI), residents care (Care Thermometer) or the lumbar load supported by caregivers (Dortmund Approach), among other factors. Each of these tools had, therefore, valuable specific and complementary features, significant of its inclusion. Thereafter, ten items were choosed to facilitate the comparison between methods. This selection was based on the similarity of content that usually have specific risk assessment methods of patient handling, also picked in a similar manner in other related studies (Tamminen-Peter et al., 2009). Furthermore, it should be noted that the selection of those items was based on relevant publications on the subject (Villarroya et al., 2016).

The scoring criterion adopted was designed to give a specific weight to each item, according to the frequency in which a given aspect is observed in all methods. The maximum score of the items, obtained from the evaluation criteria contained in each method, was assigned the higher was the frequency.

For its part, the scoring criterion adopted for each HEMPA item is explained as follows:

3. Dependency level

The value of this item has a maximum score of 3 points, obtained by combining patient mobility and patient dependence. On one hand, patient mobility (Sub-total A) is divided in five levels, mainly based on the "Mobility Gallery" of Care Thermometer method (Steer et al., 2008), each one with an assigned score as defined in Table 1:

On the other hand, regarding the patients collaboration level (Sub-total B), a score is assigned according to the handling type, as shown in Table 2:

Collaboration levels are described in "ISO/TR 12296: 2012". This standard state that the patients mobility level should be assessed considering that fully co-operating patients do not need any help in handling, partially co-operating patients need help during handling, and non co-operating patients need to be fully lifted during handling. In this sense ISO/TR 12296 indicates that handling a co-operating patient may result in a low hazard, while handling a non co-operating patient may produce a much higher hazard, as other publications denote (Knibbe and Waaijer, 2008).

To obtain the final score of the item, sub-total A and sub-total B are added and then divided by 2. Regardless the number of patients, each type of patient is multiplied by the corresponding correction factors that appear in Table 3 and then divided by the number of patients analysed; that is, a score is assigned for the combination of the different levels of mobility and collaboration.

3.1. Environmental conditions

This item, based in other similar studies (Zimring and Ulrich, 2004) has a maximum score of 1 point, distributed among the sub-items presented in Table 4, whose scores are obtained according to its suitability, as shown in the same table.

The scoring of each sub-item is done through some technical measures by an ergonomics professional, checking if the measurements obtained suite the levels of Table 4, established in the Royal Decree 486/1997, where the minimum health and safety requirements are set for workplaces (BOE nº 97, 04.23.1997). The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of rooms analysed.

4. Workspaces

This item, studied in related literature (Knibbe and Knibbe, 1996; Runy, 2004; Victorian WorkCover Authority, 2004), has a maximum score of 5 points and considers bathroom access, the toilet characteristics, the possibility of regulation of beds to handle patients at an appropriate height and the space room to perform handling in a safe way. Score is assigned based on suitability, and it is distributed among several sub-items, as shown in Table 5.

Most of the characteristics described depend on the degree of compliance with regulations governing architectural barriers. These distances should be measured to ensure that there is sufficient space to use various patient-handling devices. The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of rooms analysed.

5. Minor aids

The biomechanical effectiveness of minor aids is proven, as considered in numerous studies (Elford et al., 2000; Yassi et al., 2001; Jager et al., 2013). In that sense, this item values the available equipment to perform patients' lifting, ambulation or transferring, as well as the existence of other minor aids (transfers, sliding sheets, etc).

The item has a maximum score of 5 points. 1.25 points are

Table 1
Mobility levels and score.

Mobility level	Handling type	Score
Level A: independent patients which dress and clean up by themselves.	Safe handling: patients never depend on the caregiver.	3 points.
Level B: Patients able to support themselves while standing, using a walker or a similar aid.	Virtually safe handling: patients rarely depend on the caregiver.	2,40 points.
Level C: Patients keep standing partially, but often require a wheelchair.	Partially safe handling: patients depend on the caregiver in many situations.	1,80 points.
Level D: Patients unable to stand on their legs.	Practically unsafe handling: patients dependent on the caregiver most of the time.	1,20 points.
Level E: Patients completely bedridden.	Unsafe handling: patients always depend on the caregiver.	0,60 points.

Table 2
Collaboration levels and associated scores.

Patients collaboration level	Handling type	Score
Level 1: Fully co-operating	Safe handling, if patients are collaborators (autonomous patients that collaborate with caregivers during handling).	3 points.
Level 2: Partially co-operating	Partially safe handling, if patients are partially collaborators (patients that have a residual motor capacity and only rise partially).	2 points.
Level 3: Non co-operating	Unsafe handling, if patients do not collaborate at all (patients that cannot use upper and lower extremities, and therefore must be fully raised in transfer operations).	1 point.

Table 3
Combined scores for the different levels of mobility and collaboration.

	Level A	Level B	Level C	Level D	Level E
Level 1	3	2,70	2,40	2,10	1,80
Level 2	2,50	2,20	1,90	1,60	1,30
Level 3	2	1,70	1,40	1,10	0,80

Table 4
Score assigned for environmental conditions.

Sub-item	Adequacy	Score
Temperature	The proper temperature where work is carried out is set to be between 14 °C and 25° C.	0.25 points if appropriate, 0 points if inappropriate.
Humidity	The appropriate relative humidity is set to be between 30 and 70%.	0.25 points if appropriate, 0 points if inappropriate.
Lighting	The minimum required level for an adequate lighting is 500 Lux, since visual demands for handling patients are considered to be high.	0.25 points if appropriate, 0 points if inappropriate.
Acoustic discomfort	The equivalent continuous pressure sound level is 40 dB(A) for the period between 7:00 and 23:00 h, and 30 dB(A) for the period between 23:00 and 7:00.	0.25 points if appropriate, 0 points if inappropriate.

Table 5
Workspaces scores assignment based on their suitability.

Sub-item	Adequacy	Score
Bathroom	Bathroom access without obstacles	0.625 points if appropriate, 0 points if inappropriate.
	Door width of at least 85 cm, and adequate space for proper handling of mechanical aids.	0.625 points if appropriate, 0 points if inappropriate.
WC	Height toilet cup of at least 50 cm high and presence of lateral support bar, next to the toilet.	0.625 points if appropriate, 0 points if inappropriate.
	Adequate working space for handling a wheelchair.	0.625 points if appropriate, 0 points if inappropriate.
Adjustable beds	Possibility of mechanical regulation of beds, in both height and tilt of the headboard.	1.25 points if appropriate, 0 points if inappropriate.
Rooms	Space between beds of at least 90 cms.	0.625 points if appropriate, 0 points if inappropriate.
	Free space of at least 120 cm from bed foot to the wall.	0.625 points if appropriate, 0 points if inappropriate.

assigned for each type of existing aid among those listed in the checklist (see Annex point 4, “Minor aids”). It should be noted that each aid only rates if it previously meets all the requirements of table “Mechanical aids-Previous Requirements” (see Annex point 4, “Minor aids”), namely, that the aids are available on the unit and in a sufficient quantity, are adequate for the specific handling, and are in suitable maintenance conditions, among other aspects. To classify minor transfer aids, it was used the “ISO 9999: 2011. Assistive products for persons with disability. Classification and terminology”, as follows:

* Assistive products for transfer and turning:
- Sliding sheet.
- Transfer platform.
- Rotating disk or turntable.
* Assistive products for walking:
- Walker or standing hoist.

In this last case, it was considered a walker as an aid for the caregiver, because although it is mainly used by the patient, it reduces the load supported by the caregiver when he accompanies patients walking. The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of aids analysed.

6. Major aids

This item has a maximum score of 5 points, and values the available equipment for aiding the patient's lifting or transferring, (mechanical lifting devices, etc.) similarly to other analysis (Knibbe and Knibbe, 1996). 1.25 points are assigned for each type of existing aid of those listed in the checklist (see Annex point 5 “Major aids”). It should be noted that each aid only rates if previously meets all the requirements of table “Mechanical aids-Previous Requirements” (see Annex point 5 “Major aids”), namely, that the aids are available on the unit, in a sufficient number, are adequate for the specific handling, and are in suitable maintenance conditions, among other aspects.

To classify the major aids it has been used the standard “ISO 9999: 2011. Assistive products for persons with disability. Classification and terminology”, which resulted in the following classification:

* Assistive products for lifting:
- Patient lift.
* Assistive products for personal mobility:
- Wheelchair.
- Height-adjustable bed.
- Height-adjustable stretcher.

The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of aids analysed.

7. Transfer execution and postural analysis

This item has a maximum score of 4 points and analyses the main manual patient handling transfers, as established by several authors (Jager et al., 2010; Marras et al., 1999). For each task performed in an acceptable way, 0.40 points are assigned, considering "acceptable" the task executed without adopting awkward postures; otherwise no points are assigned. The transfers covered are:

- Lift a patient into a seated position.
- Move a patient towards the bed's head.
- Move the patient to one side of the bed.
- Raise patient's legs.
- Incline the bed's head.
- Shove a bedpan.
- Place minor aids.
- Transfer the patient from bed to bed.
- Place from bed into a chair.
- Raise the patient from sitting to standing position.

The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of patients analysed.

8. Handling outcome

This item has a maximum score of 2 points. For meeting each of the situations reflected in Table 6, a maximum of 0.50 points are assigned to the four sub-items:

The aim is to see if transfers are executed correctly, as also determined by other authors (Kjellberg et al., 2004; NHS Estates, 1997) That is, if the caregiver does not have the need to do the tasks again, or that the caregiver does not suffer physical overload by making transfers quickly or by a sudden movement of the patient agitated by fear, or because the mechanical aids must be used subsequent by an incorrect patient positioning. The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of patients analysed.

8.1. Work organization

This item has a maximum score of 4 points, and considers the work pace and breaks, the patients' ratio per caregiver, the nighttime service and the peer support for handling patients, elements also valued in related literature (Kjellberg et al., 1998). The score is assigned as indicated in Table 7:

The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of wards analysed.

9. Training

The item values a key aspect of manual patient handling (Martimo et al., 2008; Schibye et al., 2003), and has a maximum score of 2 points and assess specific training in manual patient handling, as reflected in Table 8.

The final score of the item would be an average punctuation, obtained by adding the total score achieved divided by the total number of wards analysed.

10. Risk perception

This item, based on psychosocial factors studied by other authors (Warming et al., 2009) has a maximum score of 1 point and it takes into account, by asking caregivers, if there is any physical or mental load, as shown in Table 9. It should be noted that it can be made as many queries as workers wish to participate, dividing the total score obtained by the number of participants.

10.1. Risk levels obtained by the final score

To obtain the final score and the corresponding risk level of each unit or service assessed, the partial scores of all items are summed, up to a maximum score of 30 points. This score is subdivided into three risk levels (Table 10), based on the standard UNE-EN 614–1 "Guidelines for the use of 3-zone rating system", Annex A.

The risk levels (acceptable, medium and unacceptable) were determined after discussion of the authors of this paper during content validity evaluation, just as it was done in other tools (Radovanovic and Alexandre, 2004). Also, it was previously checked if the midpoint of the method score was correctly calibrated, as reflected in paragraph 3.3.2. of this paper.

10.2. Field work

To evaluate the reliability and validity of the HEMPA method a study was carried out in various hospital wards at the public hospital Lucus Augusti (Galicia, Spain). Hospital supervisory staff had been informed and gave their consent to this research. The main tasks observed during the study were the patient's hygiene, transfers and all the in-bed postural changes –previously checking the list of categories included in HEMPA item "Transfer execution and postural analysis"–, both organizational and work environment aspects (rooms conditions, mechanical aids), as well as the ergonomic appropriateness of those tasks that represent more problems regarding work accidents by overexertion, using the checklist designed for this purpose (see Annex).

Table 6
Score assigned according to the handling outcome.

Sub-item	Score
The transfer technique used causes no pain to the patient.	0.5 points if it occurs, 0 points if it does not occurs.
The transfer technique causes no fear or uncertainty to the patient.	0.5 points if it occurs, 0 points if it does not occurs.
Transfer is not done quickly or rushing.	0.5 points if it occurs, 0 points if it does not occurs.
At the end of the transfer the patient is in an appropriate posture	0.5 points if it occurs, 0 points if it does not occurs.

Table 7
Score assigned to the work organization.

Sub-item	Score
Ratio patient/caregiver.	0.5 points if the number of patients per worker is appropriate, depending on the ratio established by the care plan according to the patient's severity.
Nocturnity.	0.25 points if there is no night work. 0.25 points if, when working at night, there is a minimum rest period of one day until the caregiver comes back to work.
Peer support.	0.5 points if usually there is peer support handling dependent patients.
Workpace and breaks.	0.25 points if patient handling is done without time pressures. 0.25 points if periodic breaks are set to rest.

Table 8
Score assigned for specific training in manual patient handling.

Sub-item	Score
Information about risks related to manual patient handling in the workplace.	0.5 points if is fulfilled, 0 points otherwise.
Theoretical and practical training in manual patient handling imparted to at least 75% of the employees of the unit.	0.5 points if is fulfilled, 0 points otherwise.
Practical training in the use of mechanical aids imparted in the last two years.	0.5 points if is fulfilled, 0 points otherwise.
Verification of the training validity, regarding its effectiveness in reducing accidents.	0.5 points if is fulfilled, 0 points otherwise.

Table 9
Risk perception score.

Sub-item	Score
a. Do you think that the working postures adopted during patient handling pose no damage to your health?	0.25 points if the answer is positive, 0 points if the answer is negative.
b. Are patients transfers planned in advance?	0.25 points if the answer is positive, 0 points if the answer is negative.
c. In your opinion, the patients handled are light or moderately heavy?	0.25 points if the answer is positive, 0 points if the answer is negative.
d. Patients transfers are not continuous or occur spaced along the work shift?	0.25 points if the answer is positive, 0 points if the answer is negative.

Table 10
Final score range and corresponding risk levels.

Risk level	Score range	Meaning
Green	From 20.01 to 30 points.	The risk of musculoskeletal disorders suffered by caregivers during patient mobilization is acceptable.
Yellow	From 10.01 to 20 points.	The risk of musculoskeletal disorders suffered by caregivers during patient mobilization is moderate.
Red	0.8 to 10 points.	The risk of musculoskeletal disorders suffered by caregivers during patient mobilization is unacceptable.

11. Results

11.1. Validation

In order to validate the HEMPA method, 10 of the 16 hospitalization units were studied with that tool, divided into 5 medical units and 5 surgical units. It should be noted that the medical units are used for medical care of patients with different diagnostic or therapeutic procedures, while the surgical units are designed to accommodate both patients who have suffered a surgical intervention and patients with diseases associated with specialties that require surgical treatment. Within the medical units, it were considered the specialisations of Paediatrics, Obstetrics, Psychiatry, Gastroenterology and Neurology, while in surgical units it were considered Traumatology, General Surgery, Internal Medicine (Surgery), Ophthalmology/Urology and Dermatology/Traumatology. In short, in the field work were included 62.50% of the total inpatient units, 52.30% of active beds and 62.56% of the hospital workers (134 nurses, 110 nursing assistants and 10 orderlies from a total of 406 workers).

11.2. Validity of formal and content aspects

The HEMPA method was previously evaluated through a Delphi study by six experts in healthcare ergonomics, all belonging to the "Group of Hospitals" that cooperates with the Spanish National Institute of Safety and Health at Work (INSHT). Delphi is a method which relies on a panel of experts who are asked for their opinion on successive rounds in order to achieve a consensus (Vernon, 2009).

Various formal and content aspects were checked through a questionnaire established for this purpose. On one side, formal aspects are those which refer to the structure of the tool, especially regarding its understandability and wording. Questions posed to experts about formal aspects were "Wording of the item is properly understood", "Options offered by the item are properly understood" and "Item responses are the most appropriate". On the other hand, content aspects are those which refer to the elements that compose the method, in particular related with the items suitability. Questions posed to experts about content aspects were "The item is well oriented to the purpose of the method", "The item belongs to the correct section", "The item contains the information necessary to assess the risk", "The score given to each item is appropriate", and "The assessment is simple and effective". In both formal and content aspects, the group of experts valued with a score from 0 to 10 the importance of each HEMPA item. When testing the validity using Delphi, Annex A (HEMPA checklist) was provided to the experts, as well as the details explained in section

Table 11
Experts rating about the formal aspects of the HEMPA method.

Item	First Round				Second Round			
	Min	Max	Average	Standard Deviation	Min	Max	Average	Standard Deviation
1.Dependency level	6	10	7,94	1,43	8	10	9,16	0,93
2.Environmental conditions	7,33	10	8,97	0,97	8,33	10	9,24	0,68
3. Workspaces	7	9,66	8,77	1,04	8,33	9,66	9,10	0,50
4. Minor aids	4	9,66	7,83	2,30	7	9,66	8,55	1,12
5. Major aids	5,33	9666	8,16	1,95	7	9,66	8,71	1,10
6. Transfer execution and postural analysis	6	10	9,33	1,63	8	10	9,66	0,81
7. Handling outcome	5,33	9	7,72	1,43	8	9	8,38	0,44
8. Work organization	6,66	10	8,88	1,72	8	10	9,38	0,95
9. Training	8	10	9,38	0,80	8,33	10	9,44	0,68
10. Risk perception	7	10	8,88	1,32	7,66	10	8,99	1,15

Table 12
Experts rating about the content aspects of the HEMPA method.

Item	First Round				Second Round			
	Min	Max	Average	Standard Deviation	Min	Max	Average	Standard Deviation
1.Dependency level	8,4	10	9,2	0,53	8,4	10	9,53	0,62
2. Environmental conditions	7	10	8,56	1,57	7	10	8,96	1,26
3. Workspaces	7,6	10	9,3	1,1	7,8	10	9,33	0,87
4. Minor aids	6,2	10	8,73	1,65	8	10	9,23	0,89
5. Major aids	6,4	10	8,73	1,58	8	10	9,23	0,88
6. Transfer execution and postural analysis	7,2	10	9,46	1,12	7,8	10	9,56	0,88
7. Handling outcome	6,6	10	9,10	1,46	8	10	9,40	0,93
8. Work organization	7,0	10	8,63	1,20	7,8	10	8,96	0,79
9. Training	8,0	10	9,43	0,89	8,0	10	9,56	0,80
10. Risk perception	7,2	10	9,10	1,05	8,0	10	9,33	0,74

2.2 of this paper. It was accepted as valid for each of the items an average score greater or equal than 7.5 points out of 10, both for formal (Table 11) and content aspects (Table 12). This result was reached after two rounds. Once the first round was made, HEMPA was modified following the suggestions of the experts. A second round with Delphi was made trying to improve the scores obtained in the first round, in order to reach a consensus.

Finally, experts agreed to consider the method as an appropriate tool to assess the risk of handling patients, both in the formal aspects and content aspects. In addition, the method has been valued as being comprehensive, as it evaluates a wide range of risk factors in the healthcare context.

11.3. Construct validity

11.3.1. Association between theoretical risk and the results of the method

Assuming that the risk level of patient handling -based on his level of mobility and collaboration-tend to be higher when the degree of dependence is also higher, a study was conducted to compare the results obtained with HEMPA in the medical (theoretically less dependent) and surgical (theoretically more dependent) units previously referred, to test in practice this initially theoretical presumption. Given the low number of cases in the sample, a parametric test and a nonparametric test for difference in means were used, namely the T Student test and the Mann-Whitney test, the latter used in a similar study (Radovanovic and Alexandre, 2004).

Table 13
Statistical descriptive study (HEMPA scores).

Units	N	Min	Max	Average	Standard Deviation	Variance
Medical	5	11,4	24,9	18,99	5,31	28,29
Surgical	5	10	15,4	13,98	2,25	5,09

Mann-Whitney test: $Z = -2.619$; $p = 0{,}000$.
T Student test: $t = 3188$; $p = 0.021$.

Data obtained is reflected on the following statistical descriptive study (Table 13).

In both tests it was found that there is a significant difference, which means that HEMPA identifies that there is higher risk (average 13,98) the greater the patient dependence is (surgical units), and there is lower risk (average 18,99) the lower the patient dependence is (medical units). It should be noted, as it was already mentioned, that HEMPA gives lower numerical scores to high risk situations.

11.3.2. Association between the method results and accident rate

To check whether HEMPA is capable of correctly predict the units with higher risk, according to the previously registered accidents, data was collected directly from the Occupational Health Unit records of the Lucus Augusti Hospital, that contains accidents due to musculoskeletal disorders compiled from 2011 to 2014. Musculoskeletal disorders comprise overexertion, upper extremities o lower extremities diseases, among many other disorders. Overexertion, for its part, refers mainly to biomechanical overload in the lower back, that is, the primal cause of accidents due to patient handling, as stated in numerous studies (Marras, 2008; Seidler et al., 2009; Menoni et al., 1999). For that reason, accidents caused by overexertion were separated from musculoskeletal disorders to be properly analysed.

Later these results were grouped in two risk levels (over 15 and under 15), as value 15 is coincident with the midpoint of the total score of HEMPA. It was checked by Odds Ratio that in the lowest-risk group (HEMPA value greater than 15 points) there were

Table 14
Relationship between HEMPA risk levels and accidents by overexertion (number of incidents).

HEMPA Score (points)	Overexertion	Other MSDs	Total
HEMPA<15	26	44	70
HEMPA>15	16	84	100
Total	42	128	170

Odds Ratio: 2.227 (IC 1,09–4551).

significantly fewer accidents by overexertion (16 accidents), while in the highest-risk group (HEMPA value lower than 15 points) there were more accidents for the same cause (26 accidents), as observed in Table 14.

11.4. Reliability

11.4.1. External reliability

The results obtained with HEMPA were compared with the results of other specific assessment tools, in particular those used in the aforementioned comparison (Villarroya et al., 2016); i.e., MAPO, DINO, PTAI, Dortmund Approach and Care Thermometer methods. To analyse the functionality of those methods, a previous fieldwork has been conducted in various medical and surgical units of a public health service hospital (Lucus Augusti Hospital, Spain). The same units were evaluated with all methods, that is, both medical units (Paediatrics, Obstetrics, Psychiatry, Gastroenterology and Neurology) as surgical units (Traumatology, General Surgery, Internal Medicine, Ophthalmology-Urology and Dermatology- Traumatology). The study was conducted by the main author of this article, who has more than ten years of experience working as an ergonomist in a public hospital. It should be noted that training in the use of the five methods was acquired before the fieldwork was made, consulting the authors of the different tools its proper use to ensure every aspect of its correct application in practice.

After finishing the field work, and before performing a statistical analysis, the results of the different methods were standardized, giving values from 1 to 100, according to a scoring logic of assigning a higher score to the situations where risk is lower. Each method was standardized differently, according to its own characteristics, as follows:

- MAPO. This method offers a lower score the lower is the risk, unlike other tools. Its scale ranges between 1 and 10. To adapt it to a 0 to 100 scale, each MAPO score was multiplied by 10, making thus equivalent to the rest of the methods.
- Care Thermometer. This tool gives a percentage score, in the sense of assigning a higher score the lower the risk so it was not necessary any standardization. It should be noted that Care Thermometer offers three percentage scores according to different risk levels (green, yellow and red). In this case, the highest score obtained has been taken as final score, since it is not possible to average the three values and obtain an overall value that integrates them.

- PTAI. This method provides a single final percentage result in scale from 0 to 100, so it was not necessary to make any standardization.
- DINO. This method provides an ascending scale of 0–1, with 0 being the higher risk and 1 the lowest. Therefore, the scores were multiplied by 100 to adapt them to a 0 to 100 scale.
- HEMPA assigns a higher score the lower is the risk, from 0 to 30 points. To be standardized into a 0 to 100 scale, the scores were multiplied by 33,33.
- Dortmund Approach. This tool does not provide a final risk level of the units analysed, so no data was standardized for the assessments made with Dortmund Approach.

Therefore, a descriptive statistical analysis, a study of differences

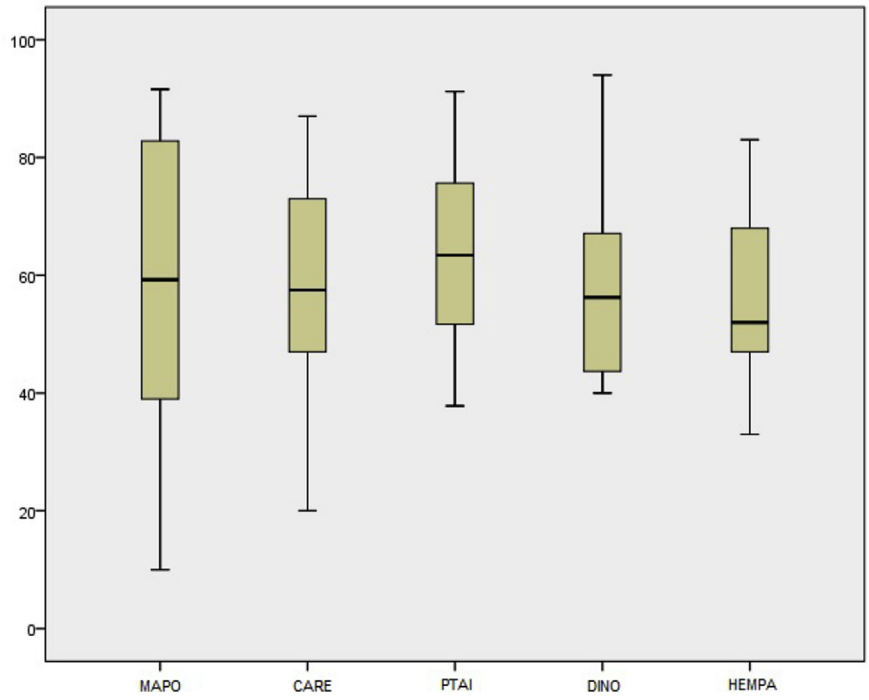

Fig. 1. Descriptive boxes diagram (Medical Units).

Table 15
T Student, Wilcoxon and Friedman analysis (Medical Units).

T Student		Wilcoxson		Friedman
Compared Methods	Significance	Compared methods	Significance	Significance
MAPO – HEMPA	,700	MAPO-HEMPA	,415	,060
CARE – HEMPA	,559	CARE-HEMPA	,327	
PTAI – HEMPA	,000	PTAI-HEMPA	,005	
DINO – HEMPA	,191	DINO-HEMPA	,241	

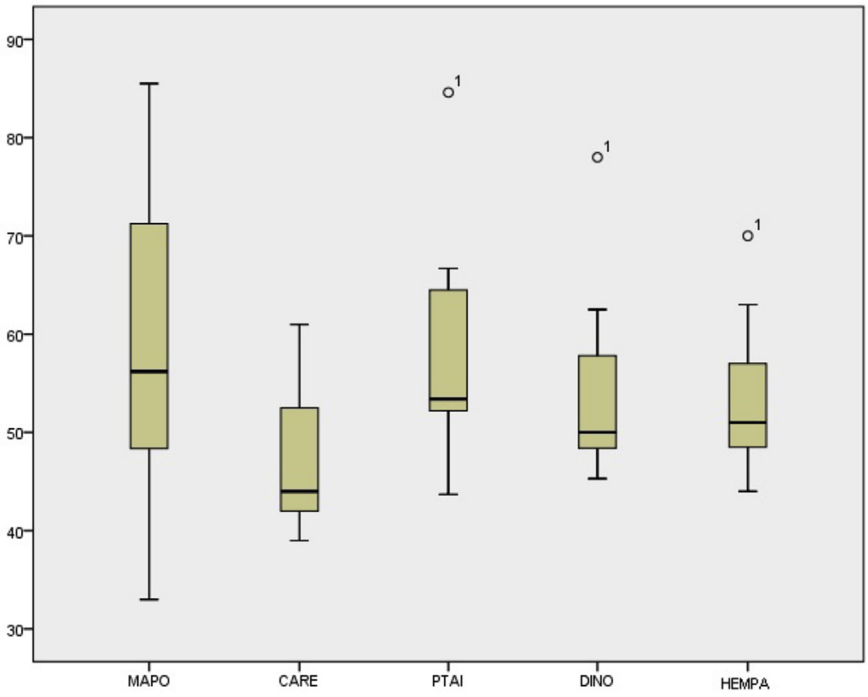

Fig. 2. Descriptive boxes diagram (Surgical Units).

through a bivariate analysis of repeated samples (with T-Student and Wilcoxon signed-rank tests) and a multivariate analysis (using Friedman test) were conducted. Fig. 1 and Table 15 present the final results (it should be noted that Dortmund Approach method was not included in the statistical analysis, because this method does not allow a final quantitative value). As it can be seen, only PTAI method shows significant differences with HEMPA, both with T Student and Wilcoxon tests. Regarding the multivariate analysis with the Friedman test, no significant differences were observed between methods, although the value of p (0.06) is close to the level of significance (0.05), probably due to the differences with PTAI method.

For surgical wards, the results are shown in Fig. 2 and Table 16. As it can be seen, there are no significant differences in either bivariate or multivariate analysis.

Based on the obtained results, it was concluded that the method HEMPA measures similarly to other specific methods, with the only exception of the medical hospital units and regarding PTAI method.

11.4.2. Inter-observer reliability

Once the formal and content aspects were evaluated by the experts, the purpose was to check if there were differences with the results of these same experts and those obtained in Lucus Augusti Hospital applying the HEMPA method. By using the HEMPA method, all experts have observed and analysed the same two units (Paediatrics and Traumatology), even though each expert has observed the corresponding bit at their respective hospitals. Experts inspected at least one room on each unit to evaluate patient's hygiene and in-bed postural changes.

Considering that HEMPA assigns a higher score to lower risk situations, between the range of 0,8 to 30 points, results from a medical unit such as Paediatrics –where patients show low dependency and low patient handling risk– were compared using the T-Student test to those obtained from a surgical unit such as Traumatology –where patients typically show high dependency and higher patient handling risk–. Table 17 shows the obtained results.

As it can be seen in the T Student test, there are significant differences among the results obtained, reaching the highest score (average 21.5) in the lower risk unit (Paediatrics) and the lowest score (average 14.4) in the higher risk unit (Traumatology). Consequently, the results of the experts confirm the correlation between risk levels and scores.

Table 16
T Student, Wilcoxon and Friedman analysis (Surgical Units).

T Student		Wilcoxson		Friedman
Compared Methods	Significance	Compared methods	Significance	Significance
MAPO – HEMPA	,314	MAPO-HEMPA	,237	,308
CARE – HEMPA	,324	CARE-HEMPA	,395	
PTAI – HEMPA	,054	PTAI-HEMPA	,075	
DINO – HEMPA	,438	DINO-HEMPA	,499	

Table 17
– HEMPA levels obtained by experts in Paediatrics and Traumatology.

	Medical Unit	Surgical Unit
	Paediatrics	Traumatology
Hospital Lucus Augusti	24,9	15,3
Expert 1	18,5	13,6
Expert 2	21,3	9,7
Expert 3	19,1	11,6
Expert 4	22,5	13,3
Expert 5	20,8	22,6
Expert 6	23,4	14,7
Average	21,5	14,4

$T = 4141$ $p < 0{,}006$.

11.4.3. Reliability of internal consistency

To check the internal consistency of the ten items of HEMPA method, we have used Cronbach's Alpha. Cronbach's Alpha was calculated with the data obtained for each item in the same medical and surgical units referred in validation section (paragraph 3.1). The final Cronbach's Alpha value was 0,732, demonstrating that the homogeneity among the items of the method was achieved. As a general rule, and according to various studies (George and Mallery, 2003; Kaplan and Saccuzzo, 1982; Huh et al., 2006), this coefficient is considered between "good" and "acceptable", when the final value ranges between 0,7 and 0,8.

12. Conclusions

HEMPA is an assessment tool mostly based in the observation of workplaces where patient handling takes place regularly. It is a method that should be used by a qualified professional through a checklist designed for this purpose (see Annex), following a scoring criteria. This tool, recommended to be used in the hospital setting, particularly in hospital wards where patients are handled, aims to provide a quantitative final result to determine whether the level of risk of musculoskeletal disorders during patients transfer is acceptable, moderate or unacceptable for the caregiver, regarding the patient's degree of dependence.

The validity of the method has been tested successfully in both its formal and content aspects by a panel of experts in healthcare ergonomics, that have agreed that this is a suitable tool for the purposes pursued. Regarding the construction validity, it has been found that the method quantifies correctly risks regarding the patient's degree of dependence. Additionally, it has also been found that the method correctly estimates the units with higher risk, regarding the previously registered accidents by overexertion. In terms of reliability, it has been found that the items of the method are homogeneous with each other. Also the method provides similar results after being used by different experts and it measures in a similar way as other specific methods used in this field.

Therefore, it can be concluded that HEMPA quantifies, in a valid and reliable way, the risks associated with physical overload resulting from manual handling of patients, and it correctly defines the exposure levels. Since it is an instrument designed to objectively cover the working conditions related to the handling of patients, it is indicated for the assessment of such occupational hazards and for preventing health damage related to its exposure. Nevertheless, although HEMPA focuses on the damage that may affect caregivers, is no less true that when presence of risk is detected, a comprehensive approach with multifactor interventions should be adopted for risk reduction. As mentioned in ISO/TR 12296, a comprehensive approach is most likely to be successful, but previously based on the results of an analytical risk assessment. Thus, a proper risk assessment is the basis for appropriate choices in risk reduction that should consider, among other aspects, the definition of a general risk management system and clear policies and procedures by the organization.

Finally, we must recognize some limitations of this study. First, the identification of risk levels regarding the degree of dependence has been limited to five medical and surgical units, and not to the all the hospital wards. In addition, in order to obtain the method reliability, results obtained in these units have been compared with those obtained by other experts in a small number of sections and, accordingly, it should be expanded to other sections in future studies. Also, in the future it would be advisable to calculate odds ratios for all three categories of HEMPA (red, yellow and green) once a larger sized sample has been analysed. Furthermore, the validation has been carried out exclusively in inpatient units of a mid-size hospital, and not in a big hospital, either in operating rooms or in other socio-sanitary environments such as home care. These aspects should be considered in future developments of this work.

Annex. checklist

Patient handling assessment method "HEMPA"

Unit data (descriptive, no score).

Unit data			
Assessment Date:	Hospital/Health Center:		Unit or Service:
Number of workers performing patient handling			
Nurses:	Nurses assistants:	Orderlies:	Others:

1 Dependency level

1. Dependency level					
a. Patient mobility (It must be checked the mobility level of patients and the handling type, from safe to unsafe)				Level A	☐ Independent patient (3p)
				Level B	☐ Patient with walker (2.40p)
				Level C	☐ Partial support (1.80p)
				Level D	☐ Dependent patient (1.20p)
				Level E	☐ Bedridden (0.60p)
Sub-Total A:	Patient 1:	Patient 2:		Patient 3:	
b. Patients collaboration (It must be checked the collaboration level of patients and the handling type, from safe to unsafe)				Level 1	☐ Fully co-operating (3p)
				Level 2	☐ Partially co-operating (2p)
				Level 3	☐ Non co-operating (1p)
Sub-Total B:	Patient 1:	Patient 2:		Patient 3:	
TOTAL: (Sub-Total A + Sub-Total B)/2	**Patient 1:**	**Patient 2:**		**Patient 3:**	

2 Environmental conditions

2. Environmental conditions						
Temperature and humidity conditions (Measure to check minimum health and safety requirements at workplaces)	Temperature (14 °C - 25° C)	Room 1	Room 2	Room 3	☐ Appropriate (0.25p)	☐ Inappropriate
	Humidity (30%–70%)	Room 1	Room 2	Room 3	☐ Appropriate (0.25p)	☐ Inappropriate
	Lighting (500 Lux)	Room 1	Room 2	Room 3	☐ Appropriate (0.25p)	☐ Inappropriate
	Acoustic discomfort (40 dB: 7:00 and 23:00 h, 30 dB 23:00 and 7:00)	Room 1	Room 2	Room 3	☐ Appropriate (0.25p)	☐ Inappropriate
TOTAL	**Room 1:**	**Room 2:**		**Room 3:**		

3 Workspaces

3. Workspaces						
Workspaces (Consider bathroom access, toilet characteristics, possibility of regulation of beds to handle patients at an appropriate height and room spaces to perform handling in a safe way)	Bathroom	Room 1	Room 2	Room 3	☐ No obstacles access (0.625p)	☐ Door width and spaces (0.625p)
	WC	Room 1	Room 2	Room 3	☐ Toilet height and support bar (0.625p)	☐ Wheelchair (0.625p)
	Height-adjustable beds	Room 1	Room 2	Room 3	☐ Height and tilt of beds (1.25p)	
	Rooms	Room 1	Room 2	Room 3	☐ Space between beds (0.625p)	☐ Space to the wall (0.625p)
TOTAL	**Room 1:**	**Room 2:**		**Room 3:**		

4 Minor aids

Mechanical aids - Previous requirements to consider for each existing aid						
Prerequisites compliance (Observe and verify the safety and adaptability requirements of each existing minor aid)	Safety requirements	Aid 1	Aid 2	Aid 3	☐ Appropriate state ☐ Adequate training for its use ☐ The aid facilitates a safely handling	
	Adaptability requirements	Aid 1	Aid 2	Aid 3	☐ The aid is on the unit, and in sufficient number for all cases in which it should be used. ☐ Adequate for handling	
REQUIREMENTS COMPLIMENTS		**Aid 1:**	**Aid 2:**	**Aid 3:**	☐ YES	☐ NO

4. Minor aids		
Minor aids (Only score each aid if it previously meets all the requirements of table "Mechanical aids-Previous Requirements")	Assistive products for transfer and turning	☐ Transfer platform. (1.25p) ☐ Rotating disk or turntable (1.25p) ☐ Sliding sheet. (1.25p)
	Assistive products for walking	☐ Walker or standing hoist (1.25p)
TOTAL		

5 Major aids

Mechanical aids - Previous requirements to consider for each existing aid.					
Prerequisites compliance (Observe and verify the safety and adaptability requirements of each existing major aid)	Safety requirements	Aid 1	Aid 2	Aid 3	☐ Appropriate state ☐ Adequate training for its use ☐ The aid facilitates a safely handling
	Adaptability requirements	Aid 1	Aid 2	Aid 3	☐ The aid is on the unit, and in sufficient number for all cases in which it should be used. ☐ Adequate for handling
REQUIREMENTS COMPLIMENTS		**Aid 1:**	**Aid 2:**	**Aid 3:**	☐ YES ☐ NO

5. Major aids		
Major aids (Only score each aid if it previously meets all the requirements of table "Mechanical aids-Previous Requirements")	Assistive products for lifting Assistive products for personal mobility	☐ Patient Lift (1.25p) ☐ Wheelchair (1.25p) ☐ Height-adjustable bed (1.25p) ☐ Height-adjustable stretcher (1.25p)
TOTAL		

6 Transfer execution and postural analysis

6. Transfer execution and postural analysis				Handling execution		Safe execution (no awkward postures adopted)	
				Yes	No	Acceptable (0.40p)	Unacceptable
Lift a patient into a seated position.	Patient 1	Patient 2	Patient 3				
Move a patient towards the bed's head	Patient 1	Patient 2	Patient 3				
Move the patient to one side of the bed.	Patient 1	Patient 2	Patient 3				
Raise patient's legs.	Patient 1	Patient 2	Patient 3				
Incline the bed's head.	Patient 1	Patient 2	Patient 3				
Shove a bedpan.	Patient 1	Patient 2	Patient 3				
Place minor aids.	Patient 1	Patient 2	Patient 3				
Transfer the patient from bed to bed.	Patient 1	Patient 2	Patient 3				
Place from bed into a chair	Patient 1	Patient 2	Patient 3				
Raise the patient from sitting to standing position	Patient 1	Patient 2	Patient 3				
TOTAL:	**Patient 1:**		**Patient 2:**		**Patient 3:**		

7 Handling outcome

7. Handling outcome					
Handling completion and patient position	The transfer technique used causes no pain to the patient.	Patient 1	Patient 2	Patient 3	☐ Happens (0.5p) ☐ Does not happens
	The transfer technique causes no fear or uncertainty to the patient.	Patient 1	Patient 2	Patient 3	☐ Happens (0.5p) ☐ Does not happens
	Transfer is not done quickly or rushing.	Patient 1	Patient 2	Patient 3	☐ Happens (0.5p) ☐ Does not happens
	At the end of the transfer the patient is in a functional position.	Patient 1	Patient 2	Patient 3	☐ Happens (0.5p) ☐ Does not happens
TOTAL	**Patient 1:**	**Patient 2:**		**Patient 3:**	

8 Work organization

8. Work organization					
Work organization (Consider the patients' ratio per caregiver, the night-time service, the peer support for handling patient, the work pace and breaks)	Ratio patient -caregiver.	Ward 1	Ward 2	Ward 3	☐ Appropriate (0.5p) ☐ Inappropriate
	Nocturnity	Ward 1	Ward 2	Ward 3	☐ No night work. (0.25p) ☐ Rest (0.25p)
	Peer support.	Ward 1	Ward 2	Ward 3	☐ Yes (0.5p) ☐ No
	Work pace and breaks.	Ward 1	Ward 2	Ward 3	☐ Time pressures (0.25p) ☐ Periodic breaks (0.25p)
TOTAL	**Ward 1:**	**Ward 2:**		**Ward 3:**	

9 Training

9. Training					
Specific training in manual patient handling	Information about risks related to manual patient handling in the workplace.	Ward 1	Ward 2	Ward 3	☐ Yes (0.5p) ☐ No
	Theoretical and practical training in manual patient handling imparted to at least 75% of the employees of the unit.	Ward 1	Ward 2	Ward 3	☐ Yes (0.5p) ☐ No
	Practical training in the use of mechanical aids imparted in the last two years.	Ward 1	Ward 2	Ward 3	☐ Yes (0.5p) ☐ No
	Verification of the training validity, regarding its effectiveness in reducing accidents.	Ward 1	Ward 2	Ward 3	☐ Yes (0.5p) ☐ No
TOTAL	**Ward 1:**	**Ward 2:**		**Ward 3:**	

10 Risk perception

10. Risk perception				Yes (0.25p)	No
a. Do you think that the working postures adopted during patient handling pose no damage to your health?	Worker 1	Worker 2	Worker 3		
b. Are patients transfers planned in advance?	Worker 1	Worker 2	Worker 3		
c. In your opinion, the patients handled are light or moderately heavy?	Worker 1	Worker 2	Worker 3		
d. Patients transfers are not continuous or occur spaced along the work shift?	Worker 1	Worker 2	Worker 3		
TOTAL (Divide the total score obtained by the number of workers who answered)					

Final risk level of the unit

SUMMARY TABLE - Final risk level of the unit	
ITEM	SCORE
1. Dependency level	
2. Environmental conditions	
3. Workspaces	
4. Minor aids	
5. Major aids	
6. Transfer execution and postural analysis	
7. Handling outcome	
8. Work organization	
9. Training	
10. Risk perception	
TOTAL (Summation of all items, from 1 to 10):	

References

Ando, S., Ono, Y., Shimaoka, M., Hiruta, S., Hattori, Y., Hori, F., Takeuchi, Y., 2000. Associations of self-estimated workloads with musculoskeletal symptoms among hospital nurses. Occup. Environ. Med. 57, 211–216.

Battevi, N., Consonni, D., Menoni, O., Ricci, M., Occhipinti, E., Colombini, D., 1999. The application of a synthetic index of exposure in the manual lifting of patients: the initial validation experiences. Med. del Lav. 90 (2), 256–275. Mar-Apr.

Battevi, N., Menoni, O., Ricci, M., Cairoli, S., 2006. MAPO index for risk assessment of patient manual handling in hospital wards: a validation study. Ergonomics 49 (7), 671–687.

Bordini, L., De Vito, G., Molteni, G., Boccardi, S., 1999. Epidemiologia delle alterazioni muscoloscheletriche da sovraccarico biomeccanico del rachide nella movimentazione manuale dei pazienti. Med. del Lav. 902, 103–116.

De Castro, A., Hagan, P., Nelson, A., 2006. Prioritizing safe patient handling: the american nurses Association's handle with care campaign. J. Nurs. Adm. 36 (7–8), 363–369.

De Troyer, M., 2015. MSDs: why wholly technology-based solutions do not work. European Trade Union Institute (ETUI). HesaMag 11, 30–32.

Elford, W., Straker, L., Strauss, G., 2000. Patient handling with and without slings: an analysis of the risk of injury to the lumbar spine. Appl. Ergon. 31, 185–200.

Engkvist, I., Hagberg, M., Hijelm, W.E., Menkel, E., Ekenvall, L., 1998. The accident process preceding overexertion back pain injuries in nursing personnel. Scand. J. Work, Environ. Health 24, 367–375.

Estates, N.H.S., 1997. Healt H Building Note No. 04. In-patient Accommodation –Options for Choice. The Stationery Office, London.

Fray, M., Hignett, S., 2010. A tool to compare all patient handling interventions. In: Proceedings of the 1st International Conference on Human Factors and Ergonomics in Healthcare, 3rd International Conference on Applied Human Factors and Ergonomics, pp. 7–8, 17-20 July 2010, Miami, USA.

Fray, M., Hignett, S., 2013. TROPHI: development of a tool to measure complex, multi-factorial patient handling interventions. Ergonomics 56, 1280–1294.

Garag, A., Owen, B., 1994. Prevention of back injuries in healthcare workers. Int. J. Industrial Ergonomics 144, 315–331.

George, D., Mallery, P., 2003. SPSS for Windows Step by Step: a Simple Guide and Reference, fourth ed. Allyn & Bacon, Boston. p. 231.

Goldman, R.H., Jarrard, M.R., Kim, R., Loomis, S., Atkins, E.H., 2000. Prioriti zing back injury risk in hospital employees: application and comparison of different injury rates. J. Occup. Environ. Med. 42, 645–652.

Hignett, S., Fray, M., 2010. Manual handling in healthcare. In: Proceedings of the 1st Conference of the Federation of the European Ergonomics Societies (FEES). Bruges, Belgium, 10-12 October 2010.

Hoogendoorn, W.E., 2002. High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. Occup. Environ. Med. 59, 323–328.

Huh, J., Delorme, D., Reid, L., 2006. Perceived third-person effects and consumer attitudes on preventing and banning DTC advertising. J. Consumer Aff. 40, 90.

Jager, M., Jordan, C., Theilmeier, A., Luttmann, A., the DOLLY Group, 2010. Lumbar-load quantification and overload-risk prevention for manual patient handling. The Dortmund Approach. In: R, Mondelo, P., Karwowski, W., Saarela, K., Hale, A., Occhipinti, E. (Eds.), Proceedings 8th International Conference of Occupational Risk Prevention ORP2010. CD-Rom (9 pp.), Valencia.

Jager, M., Jordan, C., Theilmeier, A., Wortmann, N., Kuhn, S., Nienhaus, A., Luttmann, A., 2013. Lumbar-load analysis of manual patienthandling activities for biomechanical overload prevention among healthcare workers. Ann. Occup. Hyg. 57, 528–544.

Johnsson, C., Kjellberg, K., Kjellberg, A., Lagerstrom, M., 2004. A direct observation instrument for assessment of nurses' patient transfer technique (DINO). Appl. Ergon. 35, 591–601.

Kaplan, R., Saccuzzo, D., 1982. Psychological Testing. Principles, applicCations and issues. Brooks/Cole, Monterey, CA.

Karhula, K., Rönnholm, T., Sjögren, T., 2009. A method for evaluating the load of patient transfers. Occup. Saf. Health Publ. 83.

Kjellberg, K., Lindbeck, L., Hagberg, M., 1998. Method and performance: two elements of work technique. Ergonomics 41 (6), 798–816.

Kjellberg, K., Johnsson, C., Proper, K., Olsson, E., Hagberg, M., 2000. An observation instrument for assessment of work technique in patient transfer tasks. Appl. Ergon. 31, 139–150.

Kjellberg, K., Lagerstrom, M., Hagberg, M., 2004. Patient safety and comfort during transfers in relation to nurses work technique. J. Adv. Nurs. 47 (3), 251–259.

Knibbe, N.E., Knibbe, J.J., 1996. Postural Load of Nurses during Bathing and Showering of Patients: Results of a Laboratory Study. LOCOmotion, Professional Safety, USA.

Knibbe, J.J., Waaijer, E.M., 2008. Mobility Gallery. ArjoHuntleigh, Sweden.

Larese, F., Fiorito, A., 1994. Musculoskeletal disorders in hospital nurses: a comparison between two hospitals. Ergonomics 37, 1205–1211.

Leigthon, D.J., Reilly, T., 1995. Epidemiological aspects of back pain: the incidence and prevalence of back pain in nurses compared to the general population. Occup. Med. 45, 263–267.

Marras, W., 2008. The Working Back. A Systems View. Wiley-Interscience, Chichester.

Marras, W., Davies, K., Kirking, B., Bertsche, P., 1999. A comprehensive analysis of

lowback disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. Ergonomics 42 (7), 904–926.
Martimo, K.P., Verbeek, J., Karppinen, J., Furlan, A.D., Takala, E.P., Kuijer, P., Jauhianen, M., Viikari-Juntura, E., 2008. Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review. Br. Med. J. 336, 429–431.
Menoni, O., Ricci, M.G., Panciera, D., Battevi, N., Colombini, D., Occhipinti, E., Greco, A., 1999. La movimentazione manuale dei pazienti nei reparti di degenza delle structure sanitarie: valutazione del rischio, sorveglianza sanitaria e strategie preventive. Med. del Lav. 90, 2.
National Research Council and Institute of Medicine, 2001. Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Panel on Musculoskeletal Disorders and the Workplace Commission on Behavioral and Social Sciences and Education. Washington, DC.
OSHA, 2009. Ergonomics for the Prevention of Musculoskeletal Disorders: Guidelines for Nursing Homes, U.S. Department of Labor, Occupational Safety and Health Administration. Document No. OSHA 3182-3R, Washington, DC.
Radovanovic, C.A.T., Alexandre, N.M.C., 2004. Validation of an instrument for patient handling assessment. Appl. Ergon. 35, 321–328.
Runy, L.A., 2004. The patient room: universal rooms. Hosp. Health Netw. 78 (5), 36–40.
Schibye, B., Hansen, A.F., Hye-Knudsen, C.T., Essendrop, M., Bocher, M., Skotte, J., 2003. Biomechanical analysis of the effect of changing patient-handling technique. Appl. Ergon. 34 (2), 115–123.
Seidler, A., Bergmann, A., Jäger, M., Ellegast, R., Ditchen, D., Elsner, G., Grifka, J., Haerting, J., Hofmann, F., Linhardt, O., Luttmann, A., Michaelis, M., Petereit-Haack, G., Schumann, B., Bolm-Audorff, U., 2009. Cumulative occupational lumbar load and lumbar disc disease. Results of a German multi-center case-control study (EPILIFT). BMC Musculoskelet. Disord. 10, 48.
Smedley, J.P., Egger, C., Cooper, Coggon, D., 1995. Manual handling activities and risk of low back pain in nurses. Occup. Environ. Med. 52, 160–163.
Steer, L., Knibbe, H., 2008. Ensuring Optimum Care Temperature with the Care Thermometer: Validation and Use. International Hospital Federation Reference Book, 2008/2009.
Steer, L., Hanneke, J., Knibbe, J., 2008. Ensuring Optimum Care Temperature with the Care Thermometer: Validation and Use. International Hospital Federation Reference Book.
Stubbs, D., Buckle, P., Hudson, M., Baty, D., 1986. Backing out: nurse wastage associated with back pain. Int. J. Nurs. Stud. 23 (4), 325–336.
Tamminen-Peter, L., Fagerström, V., Moilanen, A., 2009. Comparison of Risk Assessment Tools of Patient Handling. Finnish Institute of Occupational Health, Turku, Finland.
UNE-EN 614-1, 2009. Safety of Machinery -Ergonomic Design Principles - Part 1: Terminology and General Principles. ICS, 13.110.
Vernon, W., 2009. The Delphi technique: a review. Int. J. Ther. Rehabilitation 16 (2), 69–76, 2.
Victorian WorkCover Authority, 2004. Designing workplaces for safer handling of patients/residents. In: Charney, W., Hudson, A. (Eds.), Back Injury Among Healthcare Workers. Causes, Solutions and Impacts. Lewis Publishers, Boca Raton, FL, pp. 179–216.
Villarroya, A., Arezes, P., Díaz-Freijo, S., Fraga, F., 2016. Comparison between five risk assessment methods of patient handling. Int. J. Industrial Ergonomics 52, 100–108.
Warming, S., Precht, D., Suadicani, P., Ebbehoj, N., 2009. Musculoskeletal complaints among nurses related to patient handling tasks and psychosocial factors based on logbook registrations. Appl. Ergon. 40, 569–576.
Yassi, A., Cooper, J., Tate, R., Gerlach, S., Muir, M., Trottier, J., Massey, K., 2001. A randomized controlled trial to prevent patient lift and transfer injuries of health care workers. Spine 26, 1739–1746. Phila Pa 1976.
Zimring, C., Ulrich, R., 2004. The role of the physical environment in the hospital of the 21st century: a once-in-a-lifetime opportunity. Cent. Health Des. 15–25.