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MAPO index for risk assessment of patient manual handling in hospital wards: a validation study

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Manual handling of disabled patients – as regards movement – is one of the major factors affecting acute low back pain of exposed nursing staff. In the absence of quantitative methods assessing this kind of risk, the Research Unit Ergonomics of Posture and Movement of Milan developed in 1997 a risk assessment method called Movement and Assistance of Hospital Patients (MAPO), which is applicable in hospital wards.

A first study conducted in 1999 allowed the identification of three levels of MAPO index corresponding with increasing probabilities of being affected by acute low back pain. In accordance with the well-known traffic light model, for MAPO index values between 0 and 1.5 the risk is considered to be absent or negligible. For values between 1.51 and 5.00 the risk is considered to be moderate. For values exceeding 5.00 the risk is considered to be high. In view of the limitations of the previous study, the results needed confirmation and so, in 2000–2001, another cross-sectional study was carried out, which included 191 hospital wards for acute and chronic patients and 2603 exposed subjects. This paper presents the analytical results of the association between the MAPO index and acute low back pain in this new data sample.

The agreement between results of the two studies indicates that the MAPO index can be used as a risk index, although with some caution, as detailed in the paper. It can assess the risk exposure level of patient manual handling in wards and can be a useful tool for planning effective preventive actions to reduce the risk of work-related musculoskeletal disorders in health-care workers looking after disabled patients.

Keywords: Manual lifting of patients; Handling patients; Low back pain; Exposure assessment; Nurses

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1. Introduction

It is by now quite clear that one of the major health problems for health-care workers in charge of non-cooperative patients is acute or chronic low back pain (Dehlin 1976, Videman *et al.* 1984, Arad and Ryan 1986, Stobbe and Plummer 1988, Colombini *et al.* 1989, Jensen 1990, Fuortes *et al.* 1994, Ono and Lagerstrom 1995, Yassi *et al.* 1995, Knibbe and Knibbe 1996, Marena and Gervino 1997, Smedley *et al.* 1997, Bordini *et al.* 1999, Colombini *et al.* 1999b, Hignett 2001). Nowadays, methods for risk assessment of patient manual handling are available, such as the one proposed by the Royal College of Nursing (1996), or posture observation methods such as OWAS (Karku *et al.* 1977) and REBA (Hignett and McAtamney 2000) making it possible to set effective preventive actions. However, the literature up to 1999, with the exception of Stobbe and Plummer's (1988) paper, had not reported quantitative risk assessment methods. That is why, starting from 1997, the Research Unit Ergonomics of Posture and Movement (EPM) of Milan set up a risk index called Movement and Assistance of Hospital Patients (MAPO) for the assessment of patient manual-handling risk in hospital wards.

In 1996 a multi-centre study was started, the results of which were published in a special issue of *La Medicina del Lavoro* (Menoni *et al.* 1999). At that time the MAPO index had been used to evaluate the risk in 222 wards with 3440 exposed subjects. The first analysis of association between exposure level and acute low back pain permitted the definition of some risk classes according to the well-known traffic light model: for MAPO index values in the range 0.5 and 1.5 the risk was considered to be absent or negligible, for values in the range 1.51 and 5.00 the risk was considered as moderate and for MAPO index values exceeding 5.00 the risk was considered to be high.

This first study using the MAPO index posed several problems (Battevi *et al.* 1999), which were analytically illustrated at a seminar held in Milan in June 2003 (Menoni 2003). These were: non-applicability of the method in some hospital wards (e.g. resuscitation and psychiatry); difficulty of defining a 'negligible or absent exposure level'; lack of consideration of the behaviour of individual workers who, with equal exposure, could carry out a different number of patient manual handlings; and, finally, inherent limitations of a cross-sectional study.

In spite of these limitations, the MAPO index (Menoni *et al.* 2004) has been widely used in Italian hospitals for both acute and long-stay patients for a number of reasons. It allows detailed analysis of the main risk determinants for low back pain in nurses, comparison of different wards and comparison of pre- and post-intervention plans. It is also possible to use it when simulating different kinds of intervention and, finally, it is a simple and rapid analysis technique (where, in practice, risk assessment in a ward requires approximately 1 h).

Since the above-mentioned study (Battevi *et al.* 1999) was a cross-sectional study and other limitations were found, it was necessary to have a confirmation of the MAPO index value ranges that were applied as the 'Traffic Light Criterion' (Menoni *et al.* 1999). That is why, using the same risk assessment methodology (MAPO index), another multi-centre study was conducted between 2000 and 2001 under the supervision of EPM, dealing with 23 Italian hospitals with 203 wards and 3063 exposed subjects. The results of this cross-sectional study are presented in this paper.

2. Materials and methods

EPM organized this multi-centre study, providing all participants (technicians and physicians) with a preliminary educational stage, lasting 12 h, which illustrated the methods for collection of exposure index (MAPO index) and identification of acute low back pain. Also, information technology supports were circulated for controlled data collection. Risk was assessed by the technical staff in charge of safety at the hospital, while damage was evaluated by occupational physicians or trained nurses. This preliminary stage was followed by several meetings held at the different hospitals, during which the degree of adherence to the proposed protocols was checked. The two variables (exposure and damage) were collected almost simultaneously in the period between February 2000 and December 2001 in order to allocate exposure calculated with MAPO index to the workers actually present in that ward. No selection of hospitals and/or wards was made, since participation was on voluntary basis; the only acceptance criterion for data was full agreement to the proposed methodological protocol.

At the end of the study, 203 wards with 3063 exposed subjects were selected. In order to study association between exposure and acute low back pain, further selections were made according to the following criteria:

a) Exclusion of wards where the number of subjects visited was not equal to or greater than 70% of the subjects exposed to patient manual handling;
b) Exclusion of wards (such as, for example, psychiatry, psychogeriatrics and resuscitation) where the MAPO index does not guarantee a correct identification of exposure levels for the specific risk.

Following these criteria, the number of wards investigated was 191, with 2980 exposed subjects. Out of these, subjects with a ward seniority less than 6 months ($n = 324$) were also not included in the MAPO index and acute low back pain association study.

2.1. *Exposure assessment*

Calculating the MAPO index needs a data recording sheet (Menoni *et al.* 2004) consisting of two parts. The first part collects all information concerning organization and training aspects through an interview with the head nurse. The second part is specifically designed for the analysis of environmental and equipment aspects and for assessment of specific subsidiary manoeuvres through an on-site inspection.

This protocol allows identification of all factors necessary for calculation of the MAPO index:

- Disabled patient/operator ratios (NC/Op and PC/Op).
- Lifting factor (LF).
- Minor aid factor (AF).
- Wheelchair factor (WF).
- Environment factor (EF).
- Training factor (TF).

2.1.1. Calculation of the factors in the MAPO index.

2.1.1.1. Disabled patient/operator ratios. It is necessary to know the number of workers employed in the unit, and assigned to manual patient handling, to give the ratio of the average number of disabled patients present in the unit to the sum of presences across the three shifts (the total number of operators; Op). Once the average number of disabled patients is known, they are further classified into 'totally non-cooperative' (NC) and 'partially cooperative' (PC) patients on the basis of their residual motor capacity and current illness. Classification as a NC patient means that the patient is unable to use their upper and lower limbs and, hence, has to be fully lifted in transfer operations. Classification as a PC patient means that the patient has residual motor capacity and, hence, is only partially lifted.

2.1.1.2. Lifting factor. Assessment of patient lifting devices combines two aspects: a sufficient number as compared to the number of NC patients; and their adequacy as compared to the unit's requirements. A 'sufficient number' means the presence of one lifting device for every eight NC patients.

'Inadequate for the unit's requirements' means a lifting device that:

- cannot be used for the type of patient normally present in the department;
- is in a poor state of repair (often broken);
- cannot be used due to the environmental features of the wards and/or bathrooms.

The value assigned to the LF varies from 0.5 to 4, as can be seen in appendix 1.

2.1.1.3. Minor aid factor. A minor aid is considered to be a piece of equipment reducing lifting frequency and/or biomechanical overload produced by certain operations to partially move the patient (sliding sheet, transfer disc, roller, ergonomic belt). Such minor aids are considered to be present when the unit is equipped with one sliding sheet plus at least two of the other aids mentioned. A reducing value (0.5) is then assigned to the factor, considering that the presence of these aids reduces the number of such operations. When minor aids are not present or are insufficient, the value assigned is 1.

2.1.1.4. Wheelchair factor. Assessment of wheelchairs and/or commodes considers two aspects in an integrated manner: sufficient number as compared to the number of disabled patients; and presence of ergonomic requirements. A sufficient number means the presence of a number of wheelchairs equal to at least half of the number of disabled patients in the unit.

For each type of wheelchair/commode, identified during on-site inspection, the following features are assessed by assigning each one a value of 1 if absent (with a maximum of 4):

- Arm rests (which should be removable);
- Back rest (which should not be cumbersome);
- Equipped with reliable brakes;
- Width not exceeding 70 cm.

The sum of the 'inadequacy' score for each type of wheelchair, multiplied by the number of wheelchairs (with the same features), gives the total score for each type of wheelchair (column score in appendix 1). The sum of the different column scores, divided by the total number of wheelchairs, gives the mean wheelchair score. This score summarizes the ergonomic appropriateness of all wheelchairs/commodes present in the unit.

It is thus possible to define the WF value by combining the two assessed aspects (sufficient number and ergonomic requirements), as shown in appendix 1. The value of this factor varies from 0.75 to 2.

2.1.1.5. Environment factor. Three sections in the data recording sheet are concerned with this factor (appendix 1) and cover analysis of bathrooms, toilets and wards.

For each section, the number of inadequacy features is identified, with scores as shown in appendix 1. The highest scores (1 or 2) are assigned to environmental aspects which, if inadequate, oblige the operators to perform a higher number of patient transfer manoeuvres. The lowest score (0.5) is assigned to presence of furniture (e.g. armchairs) not allowing the PC patient to use any residual motor capacity that they have, so that the operator has to lift the patient.

For each section (bathrooms, toilets, wards) the procedure is the same as for wheelchairs, calculating the mean score of section 'inadequacy' (MSB, MSWC, MSW). The sum of the mean scores of the three sections makes up the mean environment score (MSE), which is divided into three categories of equidistant range, expressing low, medium and high inadequacy (as seen in appendix 1). The value of the EF varies from 0.75 to 1.5.

2.1.1.6. Training factor. The last determining factor contributing to a definition of the exposure index is the specific training of operators. Experience in checking training effectiveness enabled minimum requirements to be defined for specific training adequacy based on the following features:

- Training course lasting 6 h, divided into a theoretical section and practical exercises on techniques for lifting PC patients with the least overload;
- Practical exercises on the correct use of equipment.

When training had these features, it was noted via on-site observations (even though not systematically performed) that the number of movements producing an overload on the lumbar spine considerably decreased and that the remainder were performed in a 'less overloading' manner. For these reasons, a reducing value of 0.75 was assigned to the cases of adequate training. When training simply provided information (verbally or via leaflets), no significant reduction was observed in the number of movements producing overload: therefore a TF of 1 was assigned. When no training was given, the frequency-severity of the overloading movements was increased and a TF of 2 was assigned.

2.1.2. Calculation of the MAPO index. The MAPO synthesized exposure index is calculated according to the following mathematical expression:

$$\mathrm{MAPO} = (\mathrm{NC/Op} \times \mathrm{LF} + \mathrm{PC/Op} \times \mathrm{AF}) \times \mathrm{WF} \times \mathrm{EF} \times \mathrm{TF}$$

where NC/Op is the relationship between NC patients and operators present across the three shifts, PC/Op is the ratio between PC patients and the operators present across the three shifts. Once the MAPO index had been calculated in each single ward, it was attributed to all exposed subjects, who were considered as a homogenous group for this exposure apart from each one's professional background.

2.1.3. Classification of MAPO index results. The wards included in the study were classified into four classes of MAPO index: 0–1.5; 1.51–5.00; 5.01–10.00; and greater than 10.00.

The first multi-centre study conducted in Italy in 1999, coordinated by the EPM research group, allowed different exposure levels (green, yellow and red) to be identified by key MAPO scores. The analysis (Battevi *et al.* 1999) was conducted with odds ratio (OR) (logistic regression analyses) and incidence rate ratio (Poisson regression). Considering the trend of OR with reference to negligible levels of exposure, it was possible to define the following MAPO index classification criteria and indicate the consequent preventive actions to be adopted:

- The green band corresponds to an index level between 0 and 1.5, where risk is negligible; here the prevalence of low back pain appears to be identical to those of the general population (3.5%).
- The yellow 'alert' band falls within a range of index values between 1.51 and 5, and shows that low back pain may have an incidence 2.4 times higher than the green band. At this level, it is necessary to make a medium- and long-term intervention plan for health surveillance, aid equipment and training.
- The red band, with exposure index above 5, corresponds to a higher risk, where low back pain may have an incidence up to 5.6 times higher the expected incidence. In this case, an immediate intervention plan must be made for health surveillance, aid equipment, training and environmental improvement.

2.2. *Damage assessment*

The 'damage variable' used in this study was the acute low back pain episodes, which had occurred in the previous 12 months. Such events were defined as 'presence of lumbar pain with or without irradiation obliging the patient to remain immobile for at least 2 d, or 1 d if medication was taken'. These damage variables were selected on the basis of studies (Radwin *et al.* 2001) that proved the existence of a direct relationship between biomechanical overload and painful lumbar spine stimulation, after a very short latency period if not even simultaneously. Such a relationship is confirmed by other studies (Yassi *et al.* 1995, Colombini *et al.* 1999a) showing that most accidents involving the lumbar spine reported by health-care workers appeared to be associated with patient handling with a very close if not immediate time relationship.

The damage assessment protocol included an identity data section clearly identifying the subject, affiliation ward, ward and job seniority. In addition, the trained observer asked the subject whether he/she had been moved from another ward because of problems associated with spine injury. This was to eliminate a possible confounding variable, since there might have been the case of a ward with zero or irrelevant exposure where the number of acute low back pain episodes would turn out to be overestimated. This criterion involved removal of 53 subjects from the study. In short, the number of departments and subjects considered for risk/damage association were 191 and 2063 respectively; the acute low back pain observation protocol was administered to at least 70% in each ward investigated.

2.3. *Statistical analysis*

For each subject included in the study, the response variable (acute low back pain) was considered as binary: presence of damage (at least one episode of acute low back pain in the previous year) or absence of damage.

Then OR were calculated for three increasing exposure levels (MAPO index 1.51–5, 5.01–10, and over 10) using as a reference the MAPO index level corresponding to a value in the range 0–1.5 and therefore with an absent or irrelevant exposure level in relation to patient manual handling. Crude and multivariate analyses were conducted; in particular, multivariate unconditional logistic regression models were fitted, always including gender, age and job seniority categories as potential confounding agents.

Statistical package SPSS 5.0 (SPSS Inc. Chicago, IL, USA) was used for data description analysis; logistic models were fitted using the software STATA 6.0 (StataCorp, College Station, TX, USA).

3. Results

3.1. *Description of exposure levels in the wards investigated*

Table 1 reports the different types of wards investigated by the exposure classes of MAPO index. First, it should be noted that the sample investigated included various types of wards and for each of them it was possible to identify the exposure risk level for the manual handling of patients.

On the whole, 82% of the wards had risk exposure and, of these, several fell into the high exposure range. It is not surprising that paediatrics and neonatology wards also

Table 1. Types of wards investigated and their distribution by MAPO risk classes.

	Classes of MAPO index				
Type of ward	0–1.5 %	1.51–5 %	5.01–10 %	>10 %	Total wards No
Medicine	16.4	41.8	25.4	16.4	55
Surgery	18.9	40.5	21.5	18.9	37
Cardiology	10	80	10		10
intensive cardiology care	–	75	25	–	4
Infectious diseases	–	100	–	–	2
Neurology	–	86	14	–	7
Gynaecology-Obstetrics	50	50	–	–	4
Orthopaedics	18	23.5	23.5	35	17
Pneumology	–	100	–	–	2
Otolaryngology	100	–	–	–	2
Paediatrics-Neonatology	–	100	–	–	3
Urology	–	–	100	–	2
Nephro-Dialysis	–	50	50	–	2
Chronic geriatrics	–	41.6	41.6	16.7	12
Other	31	47	19	3	32
Total	18	47	22	13	191

Table 2. Analysis of single risk determinants of patient manual handling.

Factor	Sufficient and adequate %	Inadequate or insufficient %	Absent or fully inadequate %	Total wards*
Lifting factor (LF)	17	24.2	58.8	182
Minor aids factor (AF)	1.6	–	98.4	184
Environment factor	27.7	60.7	11.5	191
Wheelchair factor	69.6	27.8	2.6	191
Training factor	7.3	13.6	79.1	191

*The total number of wards where LF or AF is indicated is less than 191 because they are only relevant in wards that have non-cooperative or partially cooperative patients.

presented a risk, since in Italy the age of hospitalized child patients may reach 18 years. Of great interest is the analysis of the single risk determinants, which are reported in table 2. Since the need for a patient-lifting device or minor aids depends on the presence of NC or PC patients respectively, it is quite understandable why the number of wards considered for these two factors is lower than the total wards considered.

Analysis of single factors associated with MAPO index level may be the basis for a risk reduction plan in order to identify intervention priorities and specific actions to decrease exposure level. As shown in table 2, in the sample of wards considered, minor aids (sliding sheet, roller, etc.) were almost absent and education and training for specific risks were deficient. For NC patients, who therefore have to be handled completely by health-care workers, in 58.8% of wards there were no lifting devices or, if they were present, they did not meet the ward requirements. Luckily, the situation was found to be better when considering the WF and the EF. The EF is of great importance considering that each structural intervention involves a major economic commitment.

3.2. *Characteristics of exposed subject samples*

Tables 3 and 4 describe the basic properties of the exposed subjects. There was a large majority of females in the population (male-female ratio 1:4), a rather low average age (37.7 years for males and 36.4 years for females) and a rather limited ward seniority (7.1 years for males and 6.5 years for females). Table 3 shows that subjects mainly ranged between 26 and 55 years of age (92.6%). Those over 55 years are scarcely represented.

Table 4 shows that in the sample considered there were major differences between ward and job seniority. Approximately 51% of subjects had worked in their present ward for less than 4 years, whereas job seniority (years of service) was fairly evenly distributed. This means that there was a rather high turnover of staff.

Table 3. Analysis of the subject sample by age and gender.

	Age class (years)					
Gender	<26 %	26–35 %	36–45 %	46–55 %	>55 %	Total No
Males	3.0	44.4	30.8	19.2	2.6	537
Females	5.4	48.1	31.1	13	2.4	2066
Total	4.9	47.3	31	14.3	2.5	2603

Table 4. Ward and job seniority classes by gender.

	Ward seniority		Job seniority	
	Males (n = 537) %	Females (n = 2066) %	Males (n = 537) %	Females (n = 2065)* %
0–4 years	51.1	50.7	21.3	17.5
5–9 years	22.2	24.5	32.6	31.9
10–14 years	11.4	14.5	14.0	24.2
>14 years	15.3	10.3	32.1	26.3

*One with data missing.

Table 5. Distribution of exposed subject sample by ward type.

	Gender		
Type of ward	Males (n = 537) %	Females (n = 2066) %	Total (n = 2603) No
Medicine	19.9	80.1	925
Surgery	23.9	76.1	489
Cardiology	23.5	76.5	102
Intensive cardiology care	37.5	62.5	32
Infectious diseases	36.6	63.4	41
Neurology	23.6	76.4	106
Gynaecology-Obstetrics	–	100	45
Orthopaedics	25.1	74.9	251
Pneumology	27.3	72.7	33
Otolaryngology	28.6	71.4	28
Paediatrics-Neonatology	–	100	42
Urology	60	40	25
Nephro-Dialysis	–	100	28
Geriatrics	4.7	95.3	212
Other	22.1	77.9	244

Table 5 provides the distribution of exposed subjects by ward type: the most frequent specialties are medicine, surgery, orthopaedics and geriatrics.

In the sample investigated, the professionals handling patients had various qualifications: professional nurse (63.2%); general nurse (23.8%); nurse assistant (9.1%); head nurse (2.9%); others (0.9%).

3.3. *Relationship between MAPO exposure index and acute low back pain episodes in the previous 12 months*

After applying the exclusion criteria, 2603 subjects in 191 wards were identified as exposed to patient handling. Table 6 shows the association between occurrence of acute low back pain in the previous year and the MAPO index.

First, the results highlight that crude OR obtained for exposure levels (MAPO index) higher than 1.5 were all positive and significantly greater than for MAPO index <1.5. In addition, it is noteworthy that for the second and third exposure ranges the trend was increasing but then tended to diminish or stabilize at the higher exposure level (MAPO >10). The OR adjusted for confounding variables (i.e.. gender, age and job seniority) did not show significant differences. These results practically reproduce those arising from the previous multi-centre study (Battevi *et al.* 1999).

In trying to understand these results, even to give a partial answer, the most probable hypothesis suggested by the results of the previous multi-centre study (Battevi *et al.* 1999) was based on the possibility of health-care workers' behaviour not corresponding to the exposure level (exposure misclassification) when a high level of patient manual-handling exposure was present. In practice, when the handling requirement is extremely high, the health-care worker does not succeed in carrying out all the handling operations required and therefore the MAPO index may overestimate exposure. Should this hypothesis be realistic, a difference would be expected between the behaviours in 'medically oriented' wards and in 'surgically oriented' ones. Patient handling

Table 6. Association between MAPO index and occurrence of acute low back pain in the previous year.

	Acute low back pain in the previous year					
	Negative	Positive	Crude OR (95% CI)		Adjusted OR (95% CI)*	
MAPO index						
0–1.5†	338	19	1	–	1	–
1.51–5	1024	140	2.43	1.43–3.99	2.36	1.43–3.87
5.01–10	515	93	3.21	1.91–5.39	3.13	1.87–5.24
>10	407	67	2.92	1.71–5.00	2.83	1.66–4.82
Gender						
Male†	470	67	1	–	1	–
Female	1814	252	0.97	0.73–1.22	1.02	0.76–1.37
Age (years)						
15–25†	112	15	1	–	1	
26–35	1105	126	0.85	0.48–1.50	0.82	0.45–1.49
36–45	696	114	1.32	0.68–2.17	1.25	0.67–2.33
46–55	313	58	1.38	0.75–2.54	1.47	0.75–2.90
>55	58	6	0.77	0.28–2.10	0.86	0.30–2.46
Job seniority (years)‡						
0–4†	422	54	1	–	1	–
5–9	737	98	0.92	0.60–1.43	0.97	0.67–1.40
10–14	500	75	1.05	0.67–1.64	1.01	0.68–1.51
>14	624	92	1.00	0.65–1.54	0.82	0.53–1.26

*Adjusted odds ratios (OR) and 95% CI were calculated with a multivariate unconditional logistic regression model including MAPO index, gender, age and job seniority.
†Reference category.
‡One with data missing.

requirement, imposed by the critical situation of a surgical patient, should produce a lower exposure classification error and therefore a better correspondence between the MAPO index (a priori assessing handling requirement) and the handling actually carried out in that ward.

To validate this assumption, the association between the MAPO index and occurrence of acute low back pain in the previous 12 months was investigated by selecting two ward sub-groups: those more medically oriented and those more surgically oriented. In the former case 108 wards were selected with a total of 1500 exposed subjects, while in the latter case 76 wards were selected with a total of 840 exposed subjects. Tables 7 and 8 show the results of this investigation.

Comparison of these two tables shows a difference in the trend of association between the MAPO index and occurrence of low back pain in the previous year. In the medically oriented wards (table 7) the association was marked for all MAPO index classes, with a remarkable increase between the second and third classes and a reduction in the fourth class, whereas in the surgically oriented wards (table 8) there was a continuing increase in OR with the exposure index. The confounding factors considered did not substantially alter the general picture (as shown by the adjusted OR). Therefore, the results obtained by separately analysing the medically and the surgically oriented wards appear to confirm the validity of the hypothesis.

Table 7. Association between the MAPO index and occurrence of acute low back pain in the previous year in the medically oriented wards (n = 1500).

	Acute low back pain in the previous year					
	Negative	Positive	Crude OR (95% CI)		Adjusted OR (95% CI)*	
MAPO index						
0–1.5†	120	5	1	–	1	–
1.51–5	680	98	3.45	1.37–8.71	3.45	1.37–8.69
5.01–10	266	55	4.96	1.90–12.90	4.92	1.91–12.67
> 10	247	29	2.81	1.05–7.51	2.87	1.07–7.65
Gender						
Male†	242	31	1	–	1	–
Female	1071	156	1.13	0.75–1.71	1.14	0.75–1.73
Age (years)						
15–25†	72	11	1	–	1	
26–35	646	73	0.73	0.37–1.45	0.75	0.37–1.53
36–45	400	64	1.04	0.52–2.08	1.06	0.50–2.25
46–55	161	36	1.46	0.70–3.04	1.48	0.66–3.32
> 55	34	3	0.57	0.14–2.22	0.61	0.15–2.47
Job seniority‡ (years)						
0–4†	282	33	1	–	1	–
5–9	434	60	1.21	0.68–2.15	1.12	0.70–1.79
10–14	292	45	1.27	0.70–2.30	1.17	0.70–1.96
> 14	304	49	1.31	0.73–2.34	1.08	0.62–1.87

*Adjusted odds ratios (OR) and 95% CI were calculated with a multivariate unconditional logistic regression model including MAPO index, gender, age, and job seniority.
†Reference category.
‡One with data missing.

4. Discussion

This study conveys a number of considerations worth being recalled. A positive issue is that, although investigating a sample other than the one studied in 1999, the results obtained can be nearly completely overlapped, thus confirming the validity of the first assumption in defining three exposure levels according to the scheme reported in 2.1.3 and table 9.

This statement however has to be advanced with some caution considering that:

a) The type of statistical processing carried out, calculating OR with the logistics analysis technique, would not be the most appropriate for a cross-sectional study such as the present one unless the effect assessed is rather rare (that is, with a frequency less than 10%). For higher frequencies it would be desirable to apply prevalence measurements and prevalence rate ratio. As a consequence the OR obtained can be more correctly interpreted as association measurements rather than related risk assessments.
b) The MAPO index value between 0 and 1.5 indicates an absent or negligible exposure but this figure has to be constantly monitored since there may be the case when at least one fully non-collaborative patient is present without lifting devices being available and therefore the patient has to be handled manually. As in the previous

Table 8. Association between the MAPO index and occurrence of acute low back pain in the previous year in the surgically oriented wards (n = 840).

	Acute low back pain in the previous year					
	Negative	Positive	Crude OR (95% CI)		Adjusted OR (95% CI)*	
MAPO index						
0–1.5†	162	13	1	–	1	–
1.51–5	212	23	1.43	0.70–2.90	1.33	0.65–2.73
5.01–10	208	33	2.82	1.44–5.51	1.94	0.98–3.85
> 10	152	37	3.27	1.63–6.56	2.87	1.46–5.65
Gender						
Male†	185	30	1	–	1	–
Female	549	76	0.85	0.54–1.34	0.92	0.57–1.47
Age (years)						
15–25†	30	1	1	–	1	
26–35	342	44	3.85	0.50–29.21	0.82	0.47–28.13
36–45	226	39	5.17	0.67–39.39	1.25	0.72–45.42
46–55	118	19	4.83	0.60–38.41	1.47	0.72–52.27
> 55	18	3	5.00	0.44–55.70	0.86	0.69–89.46
Job seniority (years)						
0–4†	94	15	1	–	1	–
5–9	251	32	0.55	0.24–1.24	0.69	0.35–1.35
10–14	147	26	0.95	0.42–2.14	0.82	0.39–1.69
> 14	242	33	0.66	0.30–1.44	0.51	0.23–1.13

*Adjusted odds ratios (OR) and 95% CI were calculated with a multivariate unconditional logistic regression model including MAPO index, gender, age, and job seniority.
†Reference category.

Table 9. Correspondence between MAPO index value and exposure level.

Mapo Index value	Exposure level
0–1.5	**Absent or negligible**
1.51–5.00	**Present**
> 5.00	**High**

study, however, this possibility was examined and appears not to have been present in this new data sample.

c) The MAPO index is ascribed to the single subject assuming that health-care workers of a single ward are considered as a homogenous group as regards exposure, that is, that over the year considered the manual handling carried out by the single subject was similar to, if not the same as, that of all the other ward health-care workers considered. Therefore, an assumption was made that not only the single worker's behaviour was such as not to involve a higher workload for the other group members but also that three-shift rotation (during which assistance varies markedly) was uniformly distributed among subjects.

d) A very high exposure level (MAPO index > 10) may overestimate the actual patient manual handling. This might be the reason for the difference in associations between occurrence of lower back pain and the MAPO index when considering surgically oriented wards separately from medically oriented wards. Actually the problem is still open as regards assumption of the exposure assessment method involving a number of patient handling operations considered as necessary to ensure appropriate assistance. However, this exposure overestimate could be partially explained as the 'healthy worker selection effect' typical of a cross-sectional study. Therefore, defining the MAPO exposure level more gradually by introducing a new class (MAPO >10) is not practical for the time being.

The damage variable used to study the degree of association between the MAPO index and occurrence of acute low back pain showed that low back pain episodes, which have occurred in the previous year, may be one of the damage measurements that can be used in epidemiological studies investigating the ratio between spine biomechanical overload and induced damage.

Since damage was assessed by considering occurrence of acute low back pain in the previous 12 months, the ward seniority cut-off selected might have brought about an error in data analysis. In fact, a subject who was assigned a 1-year ward seniority may have worked in that ward from a minimum of 6 months to a maximum of 18 months. It can be noted, however, that this kind of (methodological) error does not necessarily affect the analysis results since it is likely to be randomly distributed in all exposure risk classes of the MAPO index.

In addition to these remarks, mostly referring to the type of study adopted, there are others arising from the close comparison with all the hospitals participating in this research. Appropriateness of the observer's education was crucial for a correct risk level assessment with the MAPO index and, in particular, for the definition of NC or PC patients (in terms of motor capacity). Other variables concerning facilities and environment left some interpretation room to the observer, so that some moderate, but sometimes significant, variations in MAPO index quantification were possible.

In the two multi-centre studies it was always required to record the peak number of non-collaborating patients, which is a variable that in some situations may be important. In fact, there are hospitals for which their geographical position may significantly increase their population in particular periods of the year, for example, hospitals near tourist centres. In this case two MAPO indices would be calculated and later the worker's yearly average exposure would be defined as the result of a weighted average. In spite of this, analysis of risk and damage association did not take this aspect into account when the so-called peak periods were less than 15 d per year. Obviously this rationale cannot be applied to geriatric residential homes.

As regards risk assessment methodology, a number of issues still need improvement, namely:

a) Since the patient lifting device was assessed in relation to the handling needs in the particular ward, according to the type of disability as well as the paths and spaces to be covered, the result was that, when defining the LF quantitatively, the criterion defining the numerical sufficiency and the criterion regarding response to ward requirement have to be considered analytically. For numerical sufficiency, for example, the number of health-care workers present in the different shifts and ward organization will also have to be considered. For adequacy of lifting devices, more details will have to be provided to meet the different patient lifting/transport requirements.

b) Assessment of the AF is not yet fully adjusted. This figure, however, is not essential since in nearly all samples examined, no minor aid was present.
c) The definition, given by the recording protocol, of wheelchair sufficiency better suits acute patient hospitals (with very short hospital stays) than those for long hospital stays, such as geriatric wards. In fact, for the latter, a wheelchair per patient would probably be necessary while, at present, the MAPO index recording protocol considers as adequate the presence of a number of wheelchairs equal to at least half the non-collaborating patients. A practical difficulty was always encountered in connection with wheelchairs when defining the real number and the kind of wheelchair present in the ward investigated: it often happens that, because of the patients' mobility, the wheelchair stock is a dynamic variable.
d) Some environmental characteristics (not considered in the MAPO index) will have to be reassessed, such as the 3–4 section height-adjustable beds, in view of reducing the risk of patient manual handling. Another issue to be further considered concerns environments such as toilets. Actually, there are wards not using these services (e.g. resuscitation) but there are others where their use is decisive in the frequency of patient handling (e.g. geriatrics wards).

5. Conclusions

The analysis conducted in this second cross-sectional study, based on analysis of 191 wards and 2063 subjects exposed to patient manual-handling risk, confirmed the results of a previous study (Battevi *et al.* 1999) and, although the due precautions, which have been noted in the discussion, makes it possible to state that this procedure allows not only the identification of three risk levels (according to the traffic light model) but also of the risk determinants affecting a high exposure level (patient-lifting devices, minor aids, wheelchairs, environmental characteristics and training related to the specific risks).

It is maybe too early to state that the MAPO index can provide acute low back pain prediction but certainly the fact that two independent studies, conducted at different hospitals and in different periods of time, provided agreement of results confirms the validity of underlying theoretical assumptions.

Certainly, it is to be emphasized that such a micro-ergonomic approach may be the first step of a preventive strategy for this specific risk, well meeting the regulations of the EU. However, it should be supported also by a macro-ergonomic approach, which is basic for any intervention strategy. In fact, such a strategy should involve the hospital as a whole, not only the nursing staff but also medical doctors, management, accountancy offices and rehabilitation. All this has to be carefully monitored in terms of both process and results.

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Appendix 1

DATA COLLECTION SHEET FOR MAPO INDEX

HOSPITAL :__________________________**UNIT:**________________________________

TOTAL No STAFF ENGAGED IN PATIENT TRANSFER OVER THREE SHIFTS:
Morning _______ Afternoon _______ Night ___________ Total No operators (**Op**) |____|

NUMBER OF DISABLED PATIENTS/OPERATORS RATIO	
Non-cooperative patients (NC) ______mean Operators ______ =	_____ **NC/Op**
Partially cooperative patients (PC) ____mean Operators ______ =	_____ **PC/Op**

LIFTING DEVICE FACTOR (LF)	**VALUE OF LF**	
ABSENT or INADEQUATE+INSUFFICIENT lifting devices	**4**	|____| LF
INSUFFICIENT or INADEQUATE lifting devices	**2**	
ADEQUATE and SUFFICIENT lifting devices	**0.5**	

MINOR AID FACTOR (AF)	**VALUE OF AF**	
ABSENT or INSUFFICIENT minor aids	**1**	|____| **AF**
SUFFICIENT and ADEQUATE minor aids	**0.5**	

WHEELCHAIR AND COMMODES		**TYPE OF WHEELCHAIR OR COMMODE**					Total No. of wheelchairs |____|
FEATURES AND INADEQUACY SCORE OF WHEELCHAIRS AND/OR COMMODES	Score	A	B	C	D	E	
		No	No	No	No	No	
Malfunctioning brakes	1						
Not extractable armrest	1						
Cumbersome backrest	1						Total wheelchair score
Width exceeding 70 cm	1						
Column score No. wheelchairs x sum of scores							

Mean wheelchair score (**MSWh)** = Total wheelchair score/No. wheelchairs |_______| **MSWh**

WHEELCHAIR FACTOR (WF)							
Mean wheelchair score	0.5 – 1.33		1.34 – 2.66		2.67 - 4		
Numerically sufficient	YES	NO	YES	NO	YES	NO	|____| **WF**
VALUE OF WF	**0.75**	**1**	**1.12**	**1.5**	**1.5**	**2**	

STRUCTURAL FEATURES OF ENVIRONMENT

BATHROOMS (centralized or individual in rooms)		**TYPE OF BATHROOMS WITH SHOWER/BATH**					
FEATURES AND INADEQUACY SCORE OF BATHROOMS WITH SHOWER/BATH	score	A	B	C	D	E	
		No	No	No	No	No	Total no. bathrooms |____|
Free space inadequate for use of aids	2						
Door width less than 85 cm	1						Total score
Non-removable obstacles	1						For bathrooms:
Column score (No. bathrooms x sum of scores)							

Mean bathrooms score (**MSB)** = total score bathrooms/total no. bathrooms : |_______| **MSB**

TOILETS (WC) (centralized or individual in rooms)		**TYPE OF WC**					
FEATURES AND INADEQUACY SCORE OF TOILETS	score	A	B	C	D	E	
		No	No	No	No	No	Total No. WC |____|
Free space insufficient to turn wheelchair round	2						
Insufficient height of WC (below 50 cm)	1						
WC without side grips	1						
Door width less than 85 cm	1						Total WC score
Space at side of WC less than 80 cm	1						
Column score (No. WC x sum of scores)							

Mean WC score (**MSWC**) = total WC score/No. WC: |_______| **MSWC**

WARDS	score	**TYPE OF WARDS**					
FEATURES AND INADEQUACY SCORE OF WARDS		No__ Wards	No__ Wards	No__ Wards	No__ Wards	No__ Wards	Total no. wards |____|
Space between beds or between bed and wall less than 90 cm	2						
Space at bed foot less than 120 cm	2						
Unsuitable bed: needs to be partially lifted	1						
Space between bed and floor less than 15 cm	2						Total ward
Height of armchairs seat less than 50 cm	0,5						score
Column score (No. wards x sum of scores)							

Mean score wards (**MSW**) = total score wards/total no. wards |_______| **MSW**

MEAN ENVIRONMENT SCORE (MSE) = MSB + MSWC + MSW = |_______| MSE

ENVIRONMENT FACTOR (EF)				
MSE	0 – 5.8	5.9 – 11.6	11.7 – 17.5	
VALUE OF EF	**0.75**	**1.25**	**1.5**	|___| EF

TRAINING FACTOR (TF)	**TF FACTOR**	
Adequate training	**0.75**	
Only information	**1**	
No training	**2**	|___| TF

MAPO EXPOSURE INDEX

MAPO INDEX = (|_____| x |_____| + |_____| x |_____|) x |_____| x |_____| x |_____| =

NC/OP LF PC/OP AF WF EF TF