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Application of MAPO (Movement and Assistance of Hospitalized Patients) method in hospitals and nursing homes: frequency of manual patient handling-part 2

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ABSTRACT

This study examines the evolution of MAPO method for estimating the frequency of overloading tasks in healthcare workers during different shifts. The data presented were collected from 51 in-patient wards (25 hospitals and 26 nursing homes), and 917 workers: the frequency of MPH tasks is a complementary value to the MAPO exposure level, which is useful to implement a prevention plan targeted towards the reduction of overloading tasks. Based on the frequency of manual patient handling, it appears that the afternoon shift is at greatest risk, with tasks liable to cause overloading occurring within a frequency range of 70–85 per worker. The study analyzes different pieces of equipment and their relative percentages of use, concluding that, overall, they are underutilised (especially minor aids and height-adjustable beds).

Practitioner summary: The organisational data collected in hospitals and nursing homes confirms the availability of patient handling aids and equipment, but also indicates that they are underutilised with respect to the frequency of overloading tasks.

Abbreviations: MPH: manual patient handling; MAPO: Movement and Assistance of Hospitalised Patients; NH: Nursing Home; D: Disabled patients; NC: totally non-cooperative patient; PC: partially cooperative patient; LF: Lifting Factor; AF: Minor Aids Factor; WF: Wheelchair Factor; EF: Environment Factor; TF: Training Factor; EPPHE: European Panel on Patient Handling Ergonomics.

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Manual patient handling; frequency of manual patient handling; hoists; sliding sheets; ergocoach training

1. Introduction

Manual patient handling is recognised internationally as a high-risk activity for musculoskeletal disorders, as confirmed by analyses conducted by bioengineering laboratories using various biomechanical models since the early 1990s (Garg et al. 1991a, 1991b; Owen, Garg, and Jensen 1992; Garg and Owen 1993; Granata and Marras 1995; Daynard et al. 2001; Nelson et al. 2006; Jang et al. 2007).

Between 2000 and 2008 research into occupational biomechanics grew from predominantly static models, which were nonetheless able to estimate the compressive force acting on the lumbar intervertebral discs, to multidimensional models that explored the dynamics of movement; for the lumbar spine such models have underscored the importance of physical exposure factors in relation to the risk of low back pain in the health care sector (Skotte and Fallentin 2008; Marras 2008, Jager et al. 2013).

These analyses have generally indicated that lifting and repositioning tasks at the bedside of dependent patients generate highly overloading compressive forces, especially for the lumbar spine; in particular, some studies indicate that tolerance limits for the lumbar intervertebral discs are exceeded during patient handling (Marras 2008) due to both compressive and shear forces, while others propose setting different tolerance limits based on age and gender (Jager et al. 2007, 2013; Jager 2018).

An in-depth review of the aforementioned studies tells us that compressive forces on the intervertebral disc cannot be estimated directly due to the countless variables involved (i.e. type of software used in the study, patient weight, degree of patient mobility, simultaneous bending and/or torsion of the spine, number of operators performing the manoeuvre, limited working space, acceleration due to movement), however it is possible to predict that the risk of

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compressive forces will be very high if the task is performed by two operators and involves a full body lift (Marras 2008; Jager 2018). By contrast, the risk of compressive forces is high if the patient only needs partial lifting.

Another aspect that identifies the risk to which healthcare workers are exposed is frequency of patient handling: in the literature there are strong indications (Andersen et al. 2019; Ribeiro, Serranheira, and Loureiro 2017; Sherehiy, Karwowski, and Marek 2005) that frequent patient handling is associated with an increased risk of musculoskeletal pain and injury. In these studies, frequency was studied among nursing staff via a self-administered questionnaire.

Risk associated with manual patient handling has been addressed at the international level, albeit with different approaches. Since 2005, comparisons between different approaches have been facilitated by our research group, as a member of a European working group named EPPHE, and later by the direct involvement in the drafting of a specific ISO Technical Report (ISO TR 12296:2012 2012, Hignett et al. 2014).

Such comparisons with other task analysis methods such as the Dortmund Approach (Jager et al. 2007, 2013; Jager 2018) and Care Thermometer (Knibbe and Friele 1999; ISO TR 12296:2012 2012) have allowed MAPO methodology to factor in biomechanical studies (Stobbe et al. 1988; Knibbe and Friele 1999; Jager et al. 2013), and thus quantify the most highly overloading tasks, as well as to estimate the frequency of handling per operator.

In fact, the Care Thermometer emphasised the importance of considering the frequency of both manual and aided handling tasks for each patient but failed to consider the number of workers engaged in MPH tasks in each shift.

Biomechanical studies, specifically on MPH tasks (Menoni, Battevi, and Cairoli 2015; Jager 2018), quantified the compressive forces for each individual MPH task performed and categorised them in to very high/high/average/negligible.

The results of this article point out that MAPO analyses conducted over the past 5 years have made it clear that in both hospitals and nursing homes, unless training in the use of lifting aids is ongoing, the equipment present is often underutilised (Noble and Sweeney 2018) or used only for particular categories of patients (e.g. obese or resistant to being moved), hence the frequency of overloading tasks (that is, tasks performed manually by operators).

The methodological aspects outlined in this contribution, together with the details provided in the previous article (Menoni et al. 2021), allow for a more detailed description of the risk arising from patient handling, with a focus on preventive strategies for reducing said risk.

1.1. Aim

The aim of this second article is to illustrate the evolution of MAPO method for quantifying patient handling risk, by:

1. Identifying the level of biomechanical overload associated with each patient handling task performed;
2. Presenting data relating to the estimated frequency of manual patient handling in hospitals and nursing homes.

2. Materials and methods

The rationale underlying MAPO index construction (Menoni et al. 1999; Karwowski 2001; Stanton et al. 2004; Battevi et al. 2006; Battevi, Menoni, and Alvarez-Casado 2012; Cantarella et al. 2020; Naomichi et al. 2021) responds to the following questions:

- ‘what or who’ is currently handled? (disabled patients, who are categorised into totally non cooperative (NC), who must be lifted entirely during handling operations, and partially cooperative (PC), who need to be partially moved or lifted during handling operations). The term ‘cooperative’ has nothing to do with the patient’s willingness to be cooperative; it refers to the patient’s ability to assist or not assist with movements;
- what causes an increase in lifting frequency or biomechanical overload on lumbar spine? (absence or inadequacy of equipment, inadequacy of spaces and furnishing, lack of adequate work organisation, poor education and training;
- what causes awkward postures? (Absence of equipment, inadequacy of spaces and furnishing, lack of education and training).

Therefore, based on these issues, it is possible to conduct an on-site inspection and an interview with the head nurse to measure and define the following aspects:

- Usual presence and number of NC and PC patients;
- Total number of operators engaged in MPH over 24 h (Op);

Table 1. MAPO index—value and meaning of risk determinants.

Single risk factor	Values ascribable to risk factor	Definition and criteria
NC/Op	Ratio of the average number of totally non-cooperative patients (NC) to the number of operators over 24 h	
LF	0.5/2/4	Low/high ergonomic and numerical inadequacy of equipment (hoists) used to lift NC patients
PC/Op	Ratio of the average number of partially cooperative patients (PC) to operators over 24 h	
AF	0.5/1	Low/high ergonomic and numerical inadequacy of equipment used to handle PC patients
WF	0.75/1/1.12/1.5/2	Low/average/high ergonomic and numerical inadequacy of wheelchairs
EF	0.75/1.25/1.5	Low/average/high ergonomic inadequacy of spaces and furnishings used by disabled patients
TF	0.75/1/2	Low/average/high inadequacy of the training carried out on the risk associated with MPH activities.
MAPO INDEX	=	(NC/Op × LF + PC/Op × AF) × WF × EF × TF

Table 2. Lumbosacral compressive force in various biomechanical overload studies conducted in bioengineering laboratories (S: static studies; D: dynamic studies; kN: kiloNewton).

			RESULTS	
Author	Tasks	study S/D	Compressive force	Other results
Owen, Garg, and Jensen (1992)	Pull patient up in bed Turn patient over in bed Wheelchair to bed Wheelchair to toilet	S	Compressive force: from approx. 3.7 to 4.8 kN	Correlation between Borg scale and disc load
Granata and Marras (1995)	Different tasks assessed using static models (S) vs dynamic models (D)	S vs D	Static model may underestimate compressive force by 45% and shear force by 70%	
Ulin et al. (1997)	3 different manual manoeuvres NC (56 kg – 95 kg)	S	Obese patient with peak compressive force of approx. 10 kN – All manual manoeuvres with compressive force >3.5 kN	
Marras et al. (1999)	50 kg NC patient lifting vs lowering with or without aids 1 or 2 operators	D	1 operator: from 5.4 to 6.7 kN 2 operators: from 4.2 to 4.8 kN	22–28% reduction with 2 operators
Jang et al. (2007)	18 tasks identified as highly overloading NC - PC (36–42–48–75 kg) 1 operator	D	Compressive force from 3.0 kN (PC partial lifting and lower weight) to 13 kN (NC total lifting)	Patient lifting tasks put the operator at risk even if they last only seconds
Jager et al. (2013)	Forces detected for 9 different tasks, performed on 4–16 PC patients 1 operator	D	Compressive force from 1.6 to 8.9 kN 3 risk levels	Tasks performed with minor aids and adequate postures are associated with lower compressive force

- Type and frequency of patient tasks;
- Ergonomic inadequacy of working and ward environments;
- Kind, number and ergonomic characteristics of available equipment;
- Rate of equipment utilisation to carry out different tasks (% of aided total and partial lifting operations);
- Characteristics of nurses and nurses aides' training and education.

This information is summarised in a mathematical expression allowing to calculate MAPO index (Table 1):

The MAPO checklist and the methods/criteria to assign values to the risk factors (MAPO checklist legend) are available online for free (EPM RESEARCH https://urlsand.esvalabs.com/?u=http%3A%2F%2Fepmresearch.org%2Fuserfiles%2Ffiles%2F1_MAPO_checklist_2020.pdf&e=b04583e6&h=a3c00029&f=n&p=y).

2.1. Identification of the level of biomechanical overload per individual task

As mentioned in the introduction, occupational biomechanics studies have used static and dynamic biomechanical models to define the tolerance limits of compressive and shear forces applied to the lumbar spine. These tolerance limits are set for different gender, age groups and for repetitive, cumulative forces; if exceeded, they may induce biological damage to the various anatomical structures that make up the spine as a whole: intervertebral discs, ligaments and tendons, posterior joint processes (Marras 2008). Tables 2 and 3 present the results of these studies: the main physical exposure factors are excessive weight lifts (Ulin et al. 1997; Choi and Brings 2015), asymmetrical lifts and speed of handling (Granata and Marras 1995), awkward postures with significant muscle involvement, and poor coordination between the different muscular regions of the lumbar spine (Jang et al. 2007; Marras 2008).

Table 3. Age and gender related limits for lumbar-disc compressive forces (Jager 2018).

TOLERANCE LIMITS FOR LUMBOSACRAL COMPRESSIVE FORCE PER MPH (REVISED DORTMUND RECOMMENDATIONS)		
AGE	FEMALE	MALE
20 years	4.4 kN	6.0 kN
30 years	3.8 kN	5.0 kN
40 years	3.2 kN	4.1 kN
50 years	2.5 kN	3.2 kN
60 years	1.8 kN	2.3 kN

Table 4. Level of biomechanical overload for different MPH tasks.

	Compressive force overload		
Type of disabled patients	Manual lifting task	Aided task (tasks with assistive devices)	
Total (NC)	VERY HIGH	AVERAGE (if with awkward postures)	NEGLIGIBLE (no awkward postures)
Partial (PC)	HIGH		

The results of the studies mentioned in Table 1 and of the tolerance limits for compressive forces on the lumbar spine by gender and 10-year age groups allow us to conclude that, in relation to the predominantly female gender and to the average age of nurses and nurses' aides (40–50 years), all manual handling tasks involve a high or very high risk.

Thanks to the results of the aforementioned studies, MAPO methodology was able to break down the individual MPH tasks performed in various departments into compressive overload macro-groups using the following data collected during interviews:

- Number of patients normally present requiring total lifting (NC);
- Number of patients normally present requiring partial lifting (PC);
- Type of equipment normally utilised for patient handling tasks and training on the use of the equipment;
- Number and type of total or partial lifting tasks performed (both manually and with aids).

The extent of biomechanical overload caused by manual patient lifting tasks is shown below (Table 4).

2.2. Estimated frequency of manual patient handling in hospital wards and nursing homes

The MAPO method and the calculation of the frequency of overloading tasks were applied to a sample consisting of 25 hospital wards and 26 nursing homes. The interview defines:

- All tasks performed to most patients;
- The number of pairs of operators performing patient handling tasks per shift;
- The adequacy of training on how to reduce the risk of WMSDs according to MAPO criteria (EPM Research).

During the following on-site inspections the pieces of equipment available were evaluated (considering both their main ergonomic requirements and their real use in carrying out the tasks usually performed in the investigated wards) and the percentage of aided handling tasks (involving both total and partial lifting operations) was quantified.

Other aspects analysed during the inspection were the number of height-adjustable beds (3-joint and 4-section), as well as the characteristics of spaces and furnishings in bathrooms and wards that may limit the proper performance of patient handling tasks.

To estimate the frequency of MPH/operator broken down by extent of biomechanical overload of the lumbar spine, MAPO checklist takes into account:

- The number of NC and PC patients;
- The number of operators per shift and number of pairs of operators performing patient handling tasks, considering that most tasks are performed by more than one operator: out of 540 patient handling tasks observed (Vinstrup et al. 2020), 71% were performed by two or more operators;
- The number of tasks per shift associated with high or very high biomechanical overload (i.e. performed manually and with mostly NC or PC patients).

An example is provided using MAPO checklist (Figure 1) for tasks performed in a ward with 12 disabled patients, 8 requiring totally lifting (NC) and 4 partial lifting (PC).

Of the 8 NC patients, 6 were bedridden due to their clinical condition: the head nurse reported that during the morning shift, most of the NC patients had to be

DISABLED PATIENTS (**D**)___**12**_____ (indicate the average number usually present in a day)
Non-cooperative patients (**NC**) no. **8**__ (no. of whom bedridden __**6**_) Partially cooperative patients (**P.C.**) no. __**4**

PATIENT HANDLING TASKS USUALLY CARRIED OUT IN EVERY SHIFT:						
MANUAL HANDLING: describe routine tasks involving total or partial patient lifting	no. of MANUAL Total Lifting operations (TL) carried out on the majority of NC patients (>50%)			no. of MANUAL Partial Lifting operations (PL) carried out on the majority of NC patients (>50%)		
indicate the number of tasks per shift involving MANUAL patient handling	**morning** A	**afternoon** B	**night** C	**morning** D	**afternoon** E	**night** F
pulling up in bed						
turning over in bed (to change position)						
bed-to-wheelchair or vice versa (v.v)						
lifting from seated to upright position or						
bed-to-stretcher or v.v						
wheelchair-to-toilet or v.v						
repositioning in wheelchair						
Lifting trunk from supine to sitting (or v.v)						
other:						
TOTAL: calculate the total for each column	**3**	**2**	**3**	**7**	**7**	**3**

Is manual patient handling usually carried out by teams of two operators? YES NO

- If YES, indicate the number of teams per shift: 1° morning _**2 teams**__ 2° afternoon **2 teams** __ 3° night __**1 team**

- If NO, indicate the number of operators per shift: 1° morning _________ 2° afternoon___________ 3° night __________

Figure 1. Estimated frequency of overloading tasks per team in each shift and summary of patient handling risk in a medical ward.

		NC		Column				PC		Column			NO. TEAMS
MORNING	(	NO.	x	A	)	+	(	NO.	x	D	)	/	Teams morning
AFTERNOON	(	NO.	x	B	)	+	(	NO.	x	E	)	/	Teams afternoon
NIGHT	(	NO.	x	C	)	+	(	NO.	x	F	)	/	Teams night

Figure 2. example of patient handling tasks routinely carried out in a ward.

manually pulled up in bed three times (at different times), while most of the PC patients only needed to be manually pulled up in bed once and were subsequently lifted and transferred from bed to wheelchair, always without using aids (in the afternoon shift, patients were shifted back from wheelchair to bed).

Other manual patient handling tasks performed in the morning, afternoon and night shifts are shown in the checklist (Figure 2), while tasks routinely performed utilising equipment are not shown because they are unnecessary for the purposes of calculating the estimated frequency of overloading tasks.

In fact, to estimate the frequency of overloading tasks per individual operator across all shifts, it is first necessary to multiply the number of NC or PC patients by the number of manual tasks performed respectively in each shift, and then to divide the result by the number of pairs of operators performing patient handling tasks.

The logical process of analysis is shown in the diagram below (Figure 3).

Therefore, in the example shown in Figure 2, the estimated overall frequency of overloading tasks per worker is as calculated in Figure 1.

The overall summary for a ward can therefore be rated (Figure 1) both with a MAPO Index (expressing the simultaneous presence of multiple organisational factors, the availability and adequacy of aids, space and environment, operator training and the relationships between these factors) and with the estimated frequency of overloading tasks per operator per shift.

It is thus possible to tailor preventive strategies towards a more effective organisation of the work and towards training in the use of new equipment.

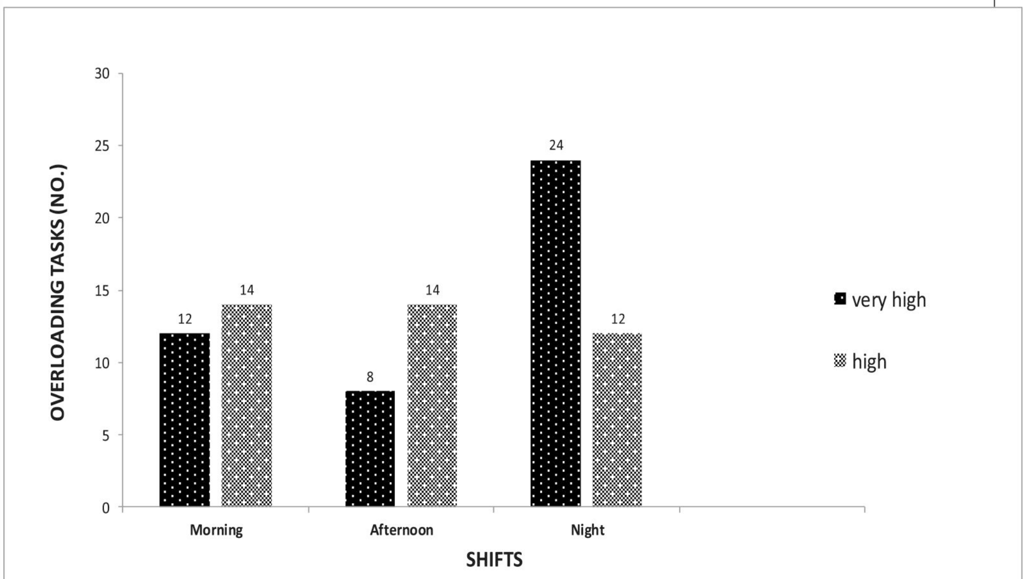
It is thus possible to define manual handling risk through different risk determinants which, in the example shown here (Figure 1), indicate an inadequate supply of equipment (LF and AF), lack of specific training (TF) and medium-high risk exposure (MAPO Index = 4.5). LF is considered adequate when its value is greater than 0.5 and completely inadequate when its value is 4: in the example above, the

Hospital: Example	Ward: Medicine	No. of Beds 20	No. of Operators (Op) 10
No. of non-cooperative patients **NC** 8		No. of partially cooperative patients **PC** 4	

SHIFT	**NC**	**x**	**COLUMN**	+	**PC**	x	**COLUMN**	/	**No. Teams**	=
MORNING	(8	x	A=3)	+	(4	x	D=7)	/	2	26
AFTERNOON	(8	x	B=2)	+	(4	x	E=7)	/	2	22
NIGHT	(8	x	C=3)	+	(4	x	F=3)	/	1	36

NC/OP	X	**LF**	+	**PC/OP**	X	**AF)**	X	**WF**	X	**EF**	X	**TF**	**MAPO**
0.8		2		0.4		1		1.5		0.75		2	**4.5** Medium Risk
MAPO RISK FACTORS													

2-nurse teams per shift	MORNING: 2	AFTERNOON: 2	NIGHT: 1



ESTIMATED FREQUENCY OF OVERLOADING TASKS PER TEAM AND PER SHIFT

Figure 3. Logical process of analysis for estimating the frequency of overloading tasks per team.

LF is partially adequate. The value and meaning of each risk determinant are illustrated in Table 1.

At the same time, the estimated frequency of action per operator indicates medium-high risk characterised by the presence of overloading tasks across all three shifts, particularly the night shift when covered by just one pair of operators.

In some wards, different patient handling activities are performed by different professionals (nurses or nurses' aides):

- In some nursing homes, nurses' aides carry out most MPH tasks, while nurses only perform them during night shifts;
- In hospital wards with a large number of nurses' aides on staff, patient handling is carried out by the latter, with nurses performing a lower percentage of MPH tasks.

In these cases, both nurses and nurses' aides in the same ward are exposed to the same MAPO Index, but with a different frequency of overloading tasks: nurses will be exposed to MPH risk with the frequency estimated only for night shifts, while nurses' aides only to the first two shifts.

Over the past three years, data has been collected on the frequency per worker of overloading tasks across different shifts in 25 hospital wards and 26 nursing homes (involving a total of 917 nurses and nurses' aides) and on the utilisation rate of available equipment.

3. Results

The sample analysed in this study is broken down here into two macro-categories: hospitals and nursing homes (Table 5); the data confirm that MPH risk is highest in nursing homes due to the larger number of disabled patients (NC and PC).

Furthermore, the comparison between the averages of the frequencies of overloading tasks per operator points out that the afternoon shift in nursing homes

Table 5. MAPO Index, disabled patients and average frequency of overloading tasks per operator and per shift (M: Morning; A: Afternoon; N: Night).

	MEAN (SD)	MIN–MAX	No. TASKS *M* (SD)	No. TASKS *A* (SD)	No. TASKS *N* (SD)
HOSPITAL WARDS ($n = 25$)			Average number of overloading tasks (SD)		
MAPO	6.3 (4.5)	0.3–18.2	33.7 (17.7)	41.1 (24.4)	29.1 (23.3)
NC	9.7 (7.8)	0–31			
PC	9.4 (5.9)	2–22			
NURSING HOMES ($n = 26$)			Average number of overloading tasks (SD)		
MAPO	7.9 (4.0)	1.1–15	49.5 (28.2)	61.2 (24.6)	33.6 (25.9)
NC	12.4 (5.7)	3–26			
PC	11.2 (6.8)	4–36			
T TEST VALUE			$p = 0.02$	$p = 0.005$	$p = 0.81$

Table 6. Frequency of overloading tasks per operator in 25 hospital wards (M: Morning; A: Afternoon; N: Night; NR: Negligible Risk; MR: Medium Risk; HR: High Risk).

	MAPO and risk determinants					No. of teams working the different shifts			Total overloading tasks, per shift and per operator			
HOSPITAL WARDS	No. beds	NC	PC	OP	MAPO	M	A	N	M	A	N	LEVEL OF XPOSURE RISK
1	9	1	2	7.0	0.3	1	1	1	8.0	8.0	0.0	NR
2	20	0	5	8.0	1.1	1.5	1.5	1	16.7	16.7	5.0	
3	15	1	5	12.0	1.1	2.5	2	1.5	17.6	16.5	7.3	
4	21	3	8	12.0	1.5	3	2	1	13.3	20.0	8,0	
5	22	6	4	9.0	1.7	2	1.5	1	31.0	26.6	18.0	MR
6	12	10	2	11.0	2.3	2.5	2	1	8.0	10.0	14.0	
7	17	3	2	8.0	2.6	1.5	1.5	1	19.3	14.0	10.0	
8	44	20	14	9.4	4.3	3	2	1	46.0	68.0	0.0	
9	22	6	4	13.0	4.6	3.5	2	1	10.8	11.0	14.0	
10	32	7	10	12.0	5.0	2.5	2	1.5	25.6	30.5	20.7	
11	19	8	7	11.6	5.5	2	2.5	1.5	27.0	27.0	10.7	HR
12	41	9	17	14.0	5.7	3	2.5	1.5	46.0	48.2	0.0	
13	20	9	9	8.7	5.8	2	1.5	1	49.5	60.0	27.0	
14	22	4	8	7.8	6.2	2	1.5	1	38.0	50.7	60.0	
15	41	4	22	12.0	6.3	2.5	2.5	1	47.2	45.6	48.0	
16	66	31	15	18.0	6.4	3.5	3.5	2	34.8	34.8	61.0	
17	32	7	18	11.9	6.7	3	2	1.5	26.3	39.5	28.7	
18	14	8	5	6.0	6.9	1.5	1	1*	61.3	77.0	46.0	
19	34	10	10	7.6	7.4	2	1	1	50.0	80.0	60.0	
20	40	14	15	14.0	8.5	3	2.5	1.5	33.6	40.4	68.6	
21	54	18	5	21.0	9.8	5.5	3.5	1.5	15.5	23.3	41.0	
22	44	22	22	10.0	12.3	3	1.5	1	66.0	73.3	66.0	
23	30	6	9	7.0	13.2	1.5	1	1	50.0	75.0	33.0	
24	24	12	12	7.0	14.4	1.5	1	1	64.0	84.0	60.0	
25	43	24	6	14.0	18.2	3	2.5	1.5	38.0	48.0	20.0	

1* refers to a single operator and not to a team of operators.

was particularly significant (p value < 0.005) compared to hospitals; the morning shift was also significant, although to a lesser extent than the afternoon shift. Table 6 shows in greater detail the main findings concerning MAPO Index, the presence of disabled patients and the estimated frequency of MPH in hospitals: it can be observed that in the wards with a high MAPO risk the range of overloading tasks per operator in day shifts is 15.5—84.

In the 26 nursing homes analysed (Table 7), the findings indicate the presence of a higher number of high-risk wards (73%) compared to hospitals and an extremely variable frequency of MPH.

Moreover, some MPH frequencies are particularly high in all three shifts. Higher frequencies of overloading tasks are observed when a low number of pairs of operators performs patient handling tasks to a high number of disabled patients per shift. For instance, Table 7 (line 14) illustrates that in the afternoon shift, one pair of operators carries out overloading tasks to 20 disabled patients (10 NC and 10 PC), performing a total of 4 lifting operations to each patient during the entire shift. These frequencies essentially confirm what previous studies have stated (Nelson and Baptiste 2004), i.e. that in an 8-h shift a nurse can lift a cumulative weight of 1.8 North American tons (equivalent to 1800 kg).

In fact, considering a patient weight range of 50–70 kg (without therefore assuming increasing numbers of overweight patients) and with operators lifting

Table 7. Frequency per operator of overloading tasks in 26 nursing homes (lines 20 e 21 refer to a single ward featuring two different types of operators).

NURSING HOMES	MAPO and risk determinants					No. of teams working the different shifts			Total overloading tasks per shift and per operator			LEVEL EXPOSURE RISK
	No. beds	NC	PC	OP	MAPO	M	A	N	M	A	N	
1	34	17	9	8.7	1.2	2.5	1.5	1	14.4	24	0	NR
2	30	16	8	8.8	1.9	2.5	1.5	1	16	26.7	0	MR
3	21	4	14	5.4	3.0	1.5	1	1*	40	60	64**	
4	35	8	18	9.6	4.0	2	2	1*	76	34	42**	
5	20	5	8	5.6	4.8	1	1	1*	87	65	78**	
6	18	11	7	6.6	5.0	2	1	1*	41	82	36**	
7	30	7	19	7.4	5.0	2	1.5	1*	60.4	80.7	90**	
8	30	9	16	7.0	5.5	1.5	1.5	1	54.7	54.7	25	HR
9	21	6	15	5.4	5.7	1	1	1*	57	57	42**	
10	54	21	17	11.0	6.0	2	2	1.5	82.5	82.5	48	
11	27	17	6	6.4	7.0	2	1	1*	23.5	41	12**	
12	28	14	9	5.9	7.0	2	1	1*	25	50	27**	
13	9	3	4	3.9	7.3	1	1*	1*	24.7	37	22**	
14	21	10	10	7.4	7.6	1.5	1	1*	46.7	80	40**	
15	40	26	12	9.0	8.0	2	2	1*	88	88	0**	
16	30	8	15	6.4	8.2	1.5	1.5	1*	34.8	41	38**	
17	18	7	8	5.0	8.3	1	1	1*	69	61	30**	
18	21	16	4	8.0	8.4	2	1.5	1*	24	24.3	28**	
19	21	13	8	6.1	8.4	2	1	1*	33	66	29**	
20	58	16	36	14.0	9.1	0	3	1	0	94.7	72	
21	58	16	36	14.0	9.1	3	3	1	82.7	94.7	72	
22	29	11	12	4.5	11.3	1	1	1*	82	82	0**	
23	19	13	6	5.1	11.7	1	1	1*	49	69	12**	
24	28	20	8	6.6	13.7	2	1	1*	40	52	36**	
25	20	16	4	7.0	14.4	1.5	1.5	1*	29.3	31.9	8**	
26	21	15	6	6.0	15.0	1	1	1*	72	78	12**	

(M: Morning; A: Afternoon; N: Night; NR: Negligible Risk; MR: Medium Risk; HR: High Risk).
1* refers to a single operator (and not a team of two operators) working in different wards.
** refers to an underestimation of the frequency of overloading tasks.

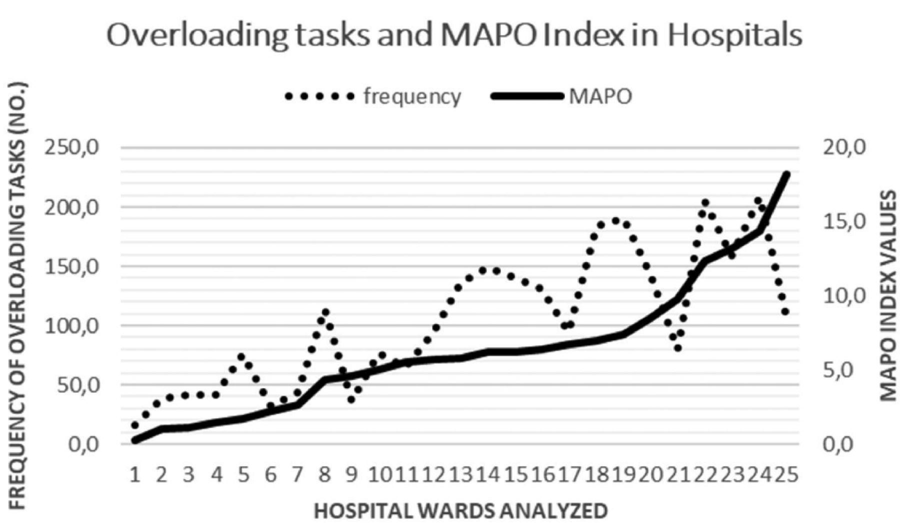


Figure 4. Graphical representation of data presented in Table 6. Total number of overloading tasks per operator, summed across shifts, and MAPO Index for each hospital.

patients in pairs, each manual handling task involves lifting at least 25 kg (and sometimes 35 kg) at a time.

Based on several high frequencies reported here (Tables 6 and 7), it is obvious that individual workers can easily lift the almost 2 tons mentioned above.

The most highly representative finding for Italian nursing homes regards the night shift where, also in our sample, the staff in 77% of facilities cover more than one ward in the same shift, therefore the frequency of patient handling is underestimated since only the frequency of the ward analysed is considered (in Table 7, this aspect is highlighted by **).

Lines 20 and 21 (Table 7) refer to a single ward featuring different frequencies of action per operator for

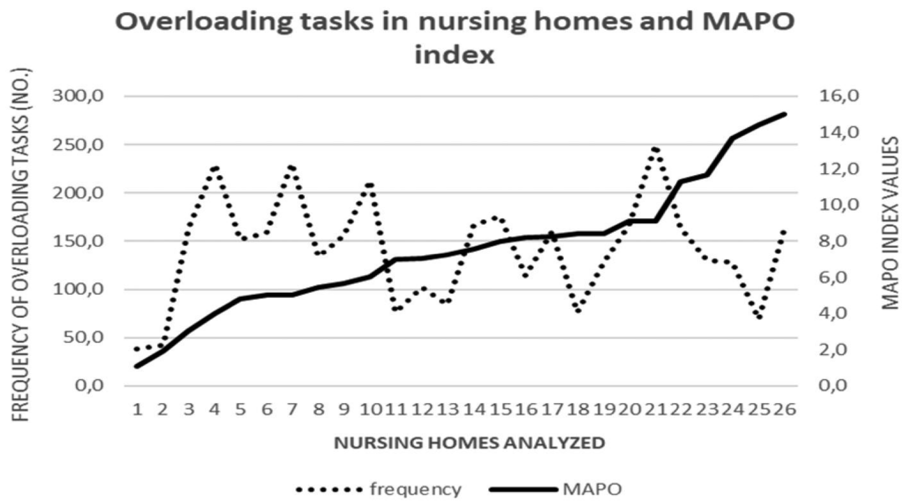


Figure 5. Graphical representation of data presented in Table 7. Total number of overloading tasks per operator, summed across shifts, and MAPO Index for each nursing home.

the two populations examined here (nurses and nurses' aides). In fact, line 20 represents the activity of nurses who, in the morning shift, perform other patient care tasks but not patient handling.

Figures 4 and 5 show the relationship of the MAPO index with the frequency of overloading tasks in different shifts: Pearson's correlation test proved to be significant in hospitals ($p < 0.01$) and not significant in nursing homes.

Figure 5 shows the frequency of MPH in nursing homes with respect to the MAPO index: it should be noted that only one out of 26 nursing homes analysed reported a negligible MAPO index.

A high frequency of overloading tasks can be observed even for medium or medium-high MAPO index levels, as shown in the data from Figure 5.

This is even more evident in facilities with a large number of disabled patients and a small number of operators. The inevitable consequence of this is that the shortage of time does not make it possible for the operators working in these facilities to perform all the necessary handing tasks with consequent worsening of the quality of the care (Spilsbury et al. 2011).

An analysis in the same hospital wards of the presence and actual use of equipment (Table 7) shows scant utilisation especially of adjustable beds and minor aids, occasional use of hoists, inadequate operator training, and lack of continuous training.

As described in Materials and Methods section, the on-site inspection allowed researchers to calculate the utilisation rate of the different types of equipment indicated in Tables 8 and 9 for each ward.

These tables illustrate data on environment and training; as far as environment is concerned, Inadequate (I) means an environment factor (EF) equal to 1.5, Partially adequate (PA) means an EF equal to 1.25, and Adequate (A) means an EF equal to 0.75; similarly, as far as training is concerned, Inadequate (I) means a training factor (TF) equal to 2, Partially adequate (PA) means a TF equal to 1 and Adequate (A) means an TF equal to 0.75 (EPM Research).

In nursing homes (Table 9) equipment is more widespread (100% have hoists, at least 71% have minor aids and 100% have adjustable beds), while the utilisation rate is high in low-medium risk facilities and only partial in high-risk facilities. Other minor aids are less utilised due to inadequate training, as for hospitals.

4. Discussion

The aim of this study is to illustrate the extent of biomechanical overload still induced by manual patient handling in hospitals and nursing homes.

Using the results of compressive force analyses performed in both bioengineering laboratories and autopsy studies, the level of risk associated with individual manual tasks was quantified using MAPO method.

Since the prevalent gender of MPH staff in this health care sector is female and that the current average age of operators is particularly high (>45 years), this study took the tolerance limits indicated by the previously cited studies (Marras 2008; Jager 2018), which, for all manual handling tasks of disabled patients, reported exceeding the limits for compressive

Table 8. MAPO Index and utilisation rate of available equipment in 25 hospital wards.

HOSPITAL WARDS	MAPO and risk determinants					Equipment and utilisation rate						Environment and training		LEVEL OF EXPOSURE RISK
	No. beds	NC	PC	OP	MAPO	Hoists	% hoist utilisation	Minor aids	% utilisation of minor aids}	Adjustable beds	% utilisation of adjustable beds	Environment	Training	
1	9	1	2	7	0.3	No	//[a]	Yes	100 %	No	//[b]	I	A	NR
2	20	0	5	8.0	1.1	No	//	Yes	0 %	Yes	0%	A	I	
3	15	1	5	12.0	1.1	Yes	33 %	Yes	0 %	No	//	PA	I	
4	21	3	8	12.0	1.5	Yes	45 %	Yes	60%	Yes	0%	PA	I	
5	22	6	4	9.0	1.7	Yes	10%	Yes	24%	No	//	PA	A	MR
6	12	10	2	11.0	2.3	Yes	100%	Yes	0%	Yes	0%	A	I	
7	17	3	2	8.0	2.6	Yes	0%	Yes	0%	Yes	0%	A	I	
8	44	20	14	9.4	4.3	Yes	0%	Yes	20%	Yes	40%	A	PA	
9	22	6	4	13.0	4.6	Yes	57%	Yes	0%	No	//	PA	I	
10	32	7	10	12.0	5.0	Yes	20%	Yes	0%	Yes	0%	PA	I	
11	19	8	7	11.6	5.5	Yes	0 %	Yes	63%	No	//	PA	I	HR
12	41	9	17	14.0	5.7	Yes	0 %	Yes	0%	Yes	0%	A	I	
13	20	9	9	8.7	5.8	Yes	27 %	Yes	0%	Yes	0%	PA	I	
14	22	4	8	7.8	6.2	Yes	25%	Yes	0%	No	//	I	I	
15	41	4	22	12.0	6.3	Yes	33 %	Yes	0%	Yes	0%	PA	I	
16	66	31	15	18.0	6.4	Yes	16 %	Yes	0 %	Yes	12%	A	I	
17	32	7	18	11.9	6.7	Yes	23%	Yes	0%	No	//	PA	I	
18	14	8	5	6.0	6.9	Yes	0%	Yes	0%	No	//	A	I	
19	34	10	10	7.6	7.4	Yes	50%	No	//[c]	Yes	0%	PA	I	
20	40	14	15	14.0	8.5	Yes	0%	Yes	0%	No	//	A	I	
21	54	18	5	21.0	9.8	Yes	6%	Yes	0%	Yes	0%	PA	I	
22	44	22	22	10.0	12.3	Yes	33%	Yes	0%	Yes	0%	PA	I	
23	30	6	9	7.0	13.2	Yes	0%	Yes	0%	Yes	0%	PA	I	
24	24	12	12	7.0	14.4	Yes	20 %	Yes	0%	Yes	0%	PA	I	
25	43	24	6	14.0	18.2	No	//	Yes	0%	Yes	27%	PA	I	

(NR: Negligible Risk; MR: Medium Risk; HR: High Risk; Environment and Training: I: inadequate; PA: partially adequate; A: adequate).
[a]Hoists are not available.
[b]Adjustable beds are not available.
[c]Minor aids are not available.

Table 9. MAPO Index and equipment utilisation rate in 26 nursing homes.

	MAPO and risk determinants					Equipment and utilisation rate						Environment and training		
NURSING HOMES	No. beds	NC	PC	OP	MAPO	Hoists	% Utilisation of hoists	Minor aids	% utilisation of minor aids	Adjustable beds	% utilisation of adjustable beds	Environment	Training	LEVEL EXPOSURE RISK
1	34	17	9	8.7	1.2	Yes	100%	Yes	38%	Yes	100%	A	PA	NR
2	30	16	8	8.8	1.9	Yes	100%	Yes	50%	Yes	100%	A	I	MR
3	21	4	14	5.4	3.0	Yes	100%	Yes	0%	Yes	0%	A	PA	
4	20	5	8	5.6	4.8	Yes	100%	No	//[a]	Yes	0%	A	I	
5	35	8	18	9.6	4.0	Yes	100%	No	//	Yes	0%	A	I	
6	18	11	7	6.6	5.0	Yes	100%	Yes	0%	Yes	0%	A	I	
7	30	7	19	7.4	5.0	Yes	100%	Yes	0%	Yes	0%	A	I	
8	30	9	16	7.0	5.5	Yes	80%	No	0%	Yes	0%	A	I	HR
9	21	6	15	5.4	5.7	Yes	40%	Yes	0%	Yes	0%	A	I	
10	54	21	17	11.0	6.0	Yes	33%	Yes	0%	Yes	0%	I	I	
11	27	17	6	6.4	7.0	Yes	40%	Yes	28%	Yes	40%	A	I	
12	28	14	9	5.9	7.0	Yes	42%	Yes	0%	Yes	0%	A	I	
13	9	3	4	3.9	7.3	Yes	33%	Yes	0%	Yes	0%	PA	I	
14	21	10	10	7.4	7.6	Yes	100%	Yes	0%	Yes	0%	PA	I	
15	40	26	12	9.0	8.0	Yes	50%	Yes	20%	Yes	25%	A	I	
16	30	8	15	6.4	8.2	Yes	0%	Yes	0%	Yes	0%	A	I	
17	18	7	8	5.0	8.3	Yes	57%	Yes	0%	Yes	0%	PA	I	
18	21	16	4	8.0	8.4	Yes	66%	Yes	10%	Yes	0%	PA	I	
19	21	13	8	6.1	8.4	Yes	50%	Yes	0%	Yes	0%	A	I	
20	58	16	36	14.0	9.1	Yes	33%	Yes	0%	Yes	0%	PA	I	
21	58	16	36	14.0	9.1	Yes	53%	Yes	0%	Yes	0%	PA	I	
22	29	11	12	4.5	11.3	Yes	28%	Yes	0%	Yes	33%	A	I	
23	19	13	6	5.1	11.7	Yes	66%	Yes	8%	Yes	0%	PA	I	
24	28	20	8	6.6	13.7	Yes	66%	Yes	0%	Yes	0%	PA	I	
25	20	16	4	7.0	14.4	Yes	57%	Yes	0%	Yes	12%	PA	I	
26	21	15	6	6.0	15.0	Yes	66%	Yes	0%	Yes	0%	PA	I	

(NR: Negligible Risk; MR: Medium Risk; HR: High Risk; Environment and Training: I: inadequate; PA: partially adequate; A: adequate).
[a]Minor aids are not available.

force on the lumbar spine in this specific working population.

By applying the parameters set out in MAPO methodology, it is possible to estimate that the frequency of overloading movements per operator may reach particularly high levels; by calculating these frequencies in each shift, it can be estimated that the cumulative spinal load per operator corresponds to the levels reported in the literature (Nelson and Baptiste 2004), i.e. cumulative loads per individual worker of up to or over 2 tons per shift.

The frequency of patient handling is an added value to the MAPO index, which expresses an overall level of exposure to the risk associated with MPH. The frequency of overloading tasks per shift is therefore added to the overall index and mainly helps in identifying the prevention plan to be implemented.

Moreover, for each department/ward, if the frequency data relating to each shift is entered into the monthly shift rotation, MAPO method can estimate the cumulative monthly load for each worker and the number of hours worked in excess of contractual or collectively agreed working hours, an aspect closely linked to understaffing (i.e. absences due to illness, accidents, difficulties in providing support staff from other departments, etc.).

Figures 4, 5 and Tables 6, 7 show that too many wards (both in hospitals and in nursing homes) experience a high frequency of overloading tasks in different shifts.

Moreover, Tables 8 and 9 highlight that there are often different pieces of equipment that are actually underutilised: this aspect underlines the usefulness of indicating the risk associated with patient handling in wards both with MAPO Index (which considers the result of the correlation between organisational, environmental, furniture and equipment, and training) and with the estimated frequency of overloading tasks per operator.

4.1. Strengths and limitations

The method proposed here does have a limitation: quantifying MPH tasks via interviews/conversations with people familiar with the organisation of the workplace may in some cases lead to over- or underestimation.

In fact, only a few Italian hospitals and nursing homes use computerised nursing records that also include MPH data; such documents could greatly facilitate the acquisition of specific information. Additional tools provided in previous articles/books (Menoni et al. 2014, Menoni et al. 2021) ensure that data collected by interview is as objective as possible, limiting potential over- or underestimates of certain parameters.

In order to overcome this limitation, the present study suggests checking the data reported during interview during visits to the various wards.

MAPO checklist identifies the tasks carried out on the majority of patients, so any calculation of the frequency of MPH will obviously be an estimate, especially in hospital wards where it is difficult to monitor all the variables that may influence the results (e.g. acute patients calling for different handling tasks, sick days of operators who are not replaced, or particular handling operations for overweight patients).

The term ''estimate' is used to refer to the frequency of patient handling because, for the majority of disabled patients, there is a likelihood of overestimating the actual frequency of action per operator; at the same time, certain tasks are performed on a smaller number of patients who are not included in the calculation, thus partly offsetting any over- or underestimates of manual tasks.

Importantly, an in-depth organisational analysis of the ways in which workers are assigned to different shifts has revealed both the risk of biomechanical overload in terms of estimated frequency of tasks and, especially in nursing homes, difficulties in providing adequate care especially during night shifts.

This aspect is particularly evident in Table 7, which show that 77% of the nursing home wards only feature one operator working in more than one ward: this means that one of the wards may present a lack of healthcare personnel for a period of time that can be more consistent if the number of wards is greater than 2. In addition, the afternoon shift proved (p value < 0.005) to be more overloading in nursing homes than in hospital wards.

In fact, understaffing is closely associated with the quality of care (Spilsbury et al. 2011): the combination of a large number of disabled patients and an insufficient number of operators can lead to less frequent patient handling activities: with a very high number of patients per operator, there is less time to perform all the necessary care-related tasks.

The main aim thus remains that of proposing a specific and targeted risk reduction plan that takes into account every aspect, including frequency of handling, and can be managed by a wide range of users (employers, head nurses, occupational physicians, prevention and protection services, trainers). Based on the tables above it is clear that although over the last

10 years patient handling equipment has been supplied to most of the wards and facilities analysed, it is still significantly underutilised due both to staff shortages (Noble and Sweeney 2018), which reduces the amount of time available to use the aids, and to inadequate and non-continuous training.

Tables 8 and 9 also suggest that greater attention should be paid to ongoing training; in fact, training proved inadequate in 88% of the hospital wards considered and in 92.3% of the nursing homes. The literature shows that the best results (significant reduction in absences due to LBP and related costs) were achieved through the purchase of equipment, specific training and involvement of management (Hignett et al. 2003).

5. Conclusion

MAPO methodology has evolved thanks to an ongoing evaluation of the various risk assessment methodologies based on task analysis and numerous studies on biomechanics at the international level: the reconstruction both of a MAPO Index associated with acute injury (Menoni et al. 1999; Battevi et al. 2006; Battevi, Menoni, and Alvarez-Casado 2012; Cantarella et al. 2020) and of an estimate of differential frequency of action across three shifts and a monthly shift (Menoni et al. 2021) suggests analysing cumulative risk if operators work an excessive number of shifts and hours with respect to contractual or collectively agreed working hours.

Such an approach enables a more detailed preventive plan to be created with a view to reducing risk of WMSDs and increasing the utilisation of available aids, by modifying individual tasks at risk of biomechanical overload, or that are habitually performed manually by operators across the three shifts. The role of lumbar anterior/posterior and lateral shear forces and relative tolerance limits (Marras 2008) in determining overall biomechanical overloads needs to be fully clarified; laboratory studies still need to be performed to investigate this aspect.

Situations in which equipment is available but underutilised and operators are inadequately trained, confirm the need, already recognised internationally (Nelson, Fragala, and Menzel 2003; Collins et al. 2004; Nelson and Fragala 2004; Karwowski and Marras 2006; Knibbe, Knibbe, and Klaassen 2012; ISO TR 12296:2012 2012) to bring on board suitably skilled and qualified staff, with the support of management (e.g. Ergocoaches, Peer Leaders, Ergo Rangers) to permanently oversee preventive strategies designed to assess overloading tasks, acquire appropriate aids, train operators in the use of the equipment, and verify the effectiveness of risk reduction programs.

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