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RESEARCH

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Variables associated with mobility levels in critically ill patients: A cohort study

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Abstract

Background: Early mobilization in the intensive care unit (ICU) helps improve patients' functional status at discharge. However, many barriers hinder this practice.

Aim and objectives: To identify mobility levels acquired by critically ill patients and their variables.

Design: A multi-centre cohort study was conducted in adult patients receiving invasive mechanical ventilation for at least 48 hours.

Methods: The primary outcome was level of mobility according to the ICU mobility scale. The secondary outcome was human resource availability and existence of ABCDEF bundle guidelines. A logistic regression was performed, based on days 3 to 5 of the ICU stay and significant association with active mobility.

Results: Six hundred and forty-two patients were included from 80 ICUs. Active moving in and out of bed was found on 9.9% of patient-days from day 8 of the ICU stay. Bed exercises, or passive transfers, and immobility were observed on 45.6% and 42.2% of patient-days, respectively. Patients achieving active mobility (189/642, 29.4%) were in ICUs with more physiotherapist hours. Active mobility was more likely with a 1:4 nurse-patient ratio (odds ratio [OR] 3.7 95% confidence interval [CI] [1.2-11.2]), high MRC sum-score (OR 1.05 95% CI [1.04-1.06]) and presence of delirium (OR 1.01 95% CI [1.00-1.02]). By contrast, active mobility was hindered by higher BMI (OR 0.92 95% CI [0.88-0.97]), a 1:3 nurse-patient ratio (OR 0.54 95% CI [0.32-0.93]), or a shift-dependent nurse-patient ratio (OR 0.27 95% CI [0.12-0.62]).
Conclusions: Immobility and passive mobilization were prevalent. A high MRC sum-score and presence of delirium are protective factors of mobilization. A 1:4 nurse-patient ratio shows a stronger association with active mobility than a 1:3 ratio.
Relevance to clinical practice: Severity-criteria-based nurse-patient ratios hinder mobilization. Active mobilization may be enhanced by using nursing-intervention-based ratios, increasing physiotherapist hours, and achieving wider application of the ABCDEF bundle, resulting in more awake, cooperative patients.

KEYWORDS
critical care nursing, early mobilization, mechanical ventilation, physical therapy, weakness

1 | INTRODUCTION

Early mobilization (EM)—defined as any volitional active exercise started within two to five days of the onset of critical illness[1,2]—can prevent bed rest complications, decrease the incidence of delirium, and improve functional status at intensive care unit (ICU) discharge.[3,4] Active exercise also improves muscle function and strength, decreases inflammation, and strengthens anti-oxidative defences, resulting in a metabolic increase in skeletal muscle and in improved microcirculation. Therefore, EM has been identified as a protective factor against intensive care unit acquired-muscle weakness (ICUAW), one aspect of post-intensive care syndrome, which is a collection of physical, mental, and cognitive dysfunctions that persist beyond the acute hospitalization stage and have a major impact on the quality of life of the growing population of ICU survivors.[5]

What is known about this topic

- The barriers that hinder EM have been extensively described in the literature: sedation and ETT use, heavy work burdens of nursing staff, and—depending on the country—lack of available physiotherapists.
- Inappropriate nurse-patient ratios have recently been found to be one of the five top barriers to EM.

What this paper adds

- This paper confirms that inappropriate nurse-patient ratios are indeed a barrier to mobilization.
- Greater mobility is achieved when the nurse-patient ratio is 1:4, in the context of intermediate ICUs where patients are less critically ill.
- Poorer mobility occurs in ICUs with ratios of 1:3, because one of the barriers to EM is fear of mobilization as a result of haemodynamic or respiratory instability, and this situation is more common among critically ill patients.

2 | BACKGROUND

The barriers that hinder EM have been extensively described in the literature.[6] Among patients receiving invasive mechanical ventilation (MV), two of the main barriers are sedation and endotracheal tube (ETT) use, as reported in observational studies in Australia and New Zealand,[7-9] Brazil,[10] United States,[11] Switzerland,[12] and Germany.[13]

Human-related barriers to EM in ICUs are insufficient resources, heavy work burdens of nursing staff, and—depending on the country—lack of available physiotherapists.[6,14-16] Other barriers identified are a lack of knowledge about the benefits of EM among health professionals, concern for patient safety because of the risk of falls, family resistance if the patient struggles with the mobilization, and haemodynamic or respiratory instability.[6,12]

3 | AIM AND OBJECTIVES

The aim of this study was to identify mobility levels achieved and associated variables in critically ill ICU patients across the country.

4 | DESIGN AND METHODS

A nationwide prospective multi-centre observational cohort study was conducted between 1 March and 6 July 2017. A call was published at the Spanish Society for Intensive Care Nurses national congress for ICUs to participate by designating named co-investigators (one nurse and one physiotherapist per ICU).

4.1 | Sample/participants

The minimum sample size was estimated to be 640 patients, based on the incidence of ICUAW found in a systematic review by Stevens et al[17] (46% in a sample of 1421 patients), a confidence level of 95%, an estimated SE of 3, and an expected loss of 5%. Inclusion criteria were adult patients receiving invasive MV for at least 48 hours in an ICU. Exclusion criteria were pregnant women, patients referred to the ICU from other hospitals, patients with primary neurologic or neuromuscular pathology, those unable to walk alone with or without mobility aids, recent limb amputees, users of orthopaedic devices (external fixators or prostheses inserted during current hospital stay), and patients with body mass index (BMI) >35.

4.2 | Research variables and measures

4.2.1 | Primary outcomes

The primary outcome was level of mobility evaluated with the ICU mobility scale (IMS). Several tools have been specifically developed in the ICU setting to assess functional outcomes,[18] of which the IMS has been found to have strong inter-rater reliability ($r = 0.83$), moderate validity ($r = 0.64$), and high responsiveness ($d = 0.8$) for measuring mobility in critically ill patients.[19,20]

The IMS was designed to standardize physiotherapists' and nurses' language when describing types of mobilization during patients' ICU stay.[21] Before the study, all nurse researchers were trained to use the scale through an online platform with post-training evaluation.

The tool is a 10-point scale, ranging from 0 (patient immobile) to 10 (independent ambulation). The scale is subdivided into a four-level classification: immobile (IMS = 0); bed exercises or passive transfers (IMS = 1-2); actively moving in or out of bed (IMS = 3-5); and marching on the spot or ambulating away from the bed space (IMS = 6-10). Mobility was studied daily by type of airway management, and categorized into three time periods (patient-day 3, patient-days 4-7, and patient-days ≥8 of the ICU stay). For the multivariate logistic regression analysis, we categorized the IMS using a binary system (<4 no active mobilization—in-bed activities—and ≥4 active mobilization—out-of-bed activities) previously applied by other authors.[22,23]

4.2.2 | Secondary outcomes

- Nurse-patient ratio: In our setting, possible ratios were 1:2, 1:3, and 1:4 (intermediate care units), shift- and patient-dependent. None of the ICUs in the study sample had a 1:1 nurse-patient ratio and we were therefore unable to explore this variable in the study.
- Physiotherapist availability: This outcome was measured as total hours per day that the ICU has a physiotherapist. Scheduled hours and the mean annual additional hours from referrals were included.
- Existence of ABCDEF bundle guidelines: Analgesia and sedation algorithms applied (yes/no, target sedation, monitoring frequency and scale, and physician- or nurse-led drug titration); daily interruption of sedation applied (yes/no); delirium prevention protocol applied (yes/no, frequency of evaluation, and reorientation measures); delirium management protocol applied (yes/no, decrease in deliriogenic, and antipsychotic drugs); EM protocol applied (yes/no, on days 2-5 of ICU stay); sleep promotion protocol applied (yes/no, environmental control measures, and sleep hygiene strategies); family engagement and empowerment strategies applied (yes/no, flexible, and extended visiting hours).

4.3 | Variables

1. ICU-related variables were ICU type (cardiothoracic, coronary care, medical, surgical, trauma or mixed (medical-surgical-trauma), and percentage of invasive MV use.
2. Patient-related variables were demographic data (age, gender, and BMI), primary diagnosis on admission, and length of ICU, and hospital stays. Indices and scores applied were Charlson for comorbidity; Barthel for disability; acute physiology and chronic health evaluation II (APACHE II) and sequential organ failure assessment (SOFA) for severity of illness; numeric rating scale or the Spanish scale to assess behavioural indicators of pain (EScala de Conductas Indicadoras de Dolor) for pain; and the richmond agitation sedation scale (RASS) for sedation. Delirium was assessed subjectively by the nurse in charge or objectively according to the confusion assessment method for the ICU (CAM-ICU), and the presence of ICUAW was assessed using the Medical Research Council (MRC) scale sum-score. This scale evaluates muscle strength with a score ranging from 0 (no muscle contraction) to 5 (full strength). Physical examination of three muscle groups in each of the upper and lower limbs results in a composite or sum score of 60. ICUAW was diagnosed for values lower than 48 out of 60 at the first measurement (baseline MRC).[24] Other variables were ventilation modes (MV with ETT or tracheostomy, or MV-free); other support techniques applied, such as continuous renal replacement therapy (CRRT) and vasoactive agents; fraction of inspired oxygen

TABLE 1 Mobility level by patient and intensive care unit (ICU) day

Mobility level	ICU day														
	3	4	5	6	7	8	9	10	11	12	13	14	15
Immobile (ICU mobility scale—IMS = 0)	504 (78.5)	430 (67.6)	368 (59.5)	323 (55.1)	302 (55.5)	268 (53.5)	240 (51.6)	219 (50.9)	193 (49.9)	181 (50.1)	158 (47.4)	142 (46)	120 (42.7)
Bed exercises or passive transfers (IMS = 1-2)	133 (20.7)	177 (27.8)	205 (33.1)	215 (36.7)	193 (35.5)	190 (37.9)	176 (37.8)	162 (37.7)	144 (37.2)	137 (38)	144 (43.2)	138 (44.7)	131 (46.6)
Actively moving in or out of bed (IMS = 3-5)	3 (0.5)	27 (4.2)	41 (6.6)	43 (7.3)	46 (8.5)	42 (8.4)	43 (9.2)	43 (10)	42 (10.9)	30 (8.3)	23 (6.9)	22 (7.1)	25 (8.9)
Marching on the spot or ambulating away from the bed space (IMS = 6-10)	2 (0.3)	2 (0.3)	5 (0.8)	5 (0.9)	3 (0.6)	1 (0.2)	6 (1.3)	6 (1.4)	8 (2.1)	13 (3.6)	8 (2.4)	7 (2.3)	5 (1.8)
Total patients on ICU day	642	636	619	586	544	501	465	430	387	361	333	309	281

Note: Data expressed as n (%) = mobility level per patient divided by total patients on that ICU day, multiplied by 100.

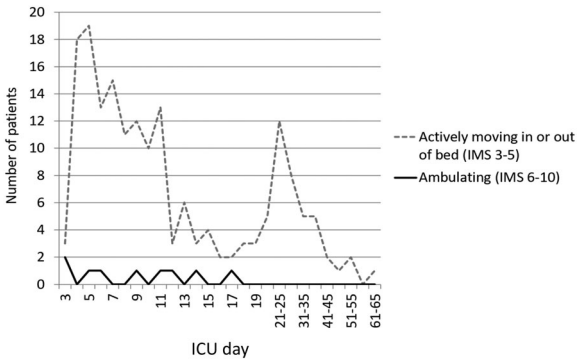

FIGURE 1 Active mobility according to days of intensive care unit stay

and positive end-expiratory pressure; and administration of drugs such as sedatives, analgesics, and neuroleptics.

Detailed definitions and descriptions of the measurement tools and protocols are provided in the Appendix S1.

4.4 | Data collection

Data were collected from day 3 of the ICU stay until ICU discharge. The nurse investigator was responsible for recording the daily IMS score and patient-related variables, except for the MRC sum-score, which was assessed and recorded daily by the physiotherapist investigator. All investigators accessed the study data log with usernames and secure passwords.

4.5 | Data analysis

Categorical variables were expressed as frequency and percentage, using Fisher or Chi-square tests for between-group comparisons. Quantitative variables were expressed as mean and SD for normal distribution and median and interquartile range (IQR) for non-normal distribution, and groups were compared using the Student's *t*-test or Mann-Whitney *U* test. For the multivariate logistic regression analysis, a stepwise backward model was fitted with data from days 3 to 5 of the ICU stay. This timeframe was based on the most recent systematic reviews[25,26] that recommend mobilization within 48 to 72 hours of starting invasive MV. Of the studies that suggest a definition of EM, nearly half consider 'early' to mean within 5 days of ICU admission. The model was adjusted for all variables that showed significance in the bivariate analysis. Non-significant factors ($P > .05$) were eliminated one at a time until all remaining factors had a significant association with active mobility (IMS ≥4). Goodness-of-fit was assessed using the Hosmer-Lemeshow test and discrimination using the area under the receiver operating characteristic (AUC-ROC) curve. Accuracy was considered good when the AUC-ROC curve ranged from 0.70 to 0.80, and excellent when it was greater than 0.80. The adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated for each factor that was significant in the logistic regression model. Data were analysed using SAS 9.2 software (SAS Institute, Cary, North Carolina).

TABLE 2 Baseline and clinical characteristics of the patients, by level of mobility achieved by the patients during their intensive care unit (ICU) stay

	No active mobility (IMS <4) n = 453 patients	Active mobility (IMS ≥4) n = 189 patients	*P* value
Age (years)	67 (55-75)	63 (51-71)	.002
Women	131 (28.9)	64 (33.9)	.2
Diagnoses on ICU admission			
Sepsis	90 (19.9)	35 (18.5)	.7
Trauma	29 (6.4)	4 (2.1)	.02
Neurosurgery	14 (3.1)	0 (0)	.01
Cardiac surgery	32 (7.1)	25 (13.2)	.01
Other surgery	75 (16.6)	41 (21.7)	.1
Overdose	8 (18)	4 (2.1)	.7
Other medical diagnoses	205 (45.3)	80 (42.3)	.5
BMI	27 (24.6-29.7)	25.7 (23.3-29.3)	.001
Barthel at admission	100 (95-100)	100 (100-100)	.6
Charlson	5 (1-7)	4 (2-6)	.1
APACHE II[a]	22 (17-27)	20 (16-26)	.07
SOFA score (maximum during ICU stay)[a]	10 (7-12)	8 (6-11)	.1
Tracheostomy tube	116 (25.6)	50 (26.5)	.4
Days of ICU stay	14 (9-22)	13 (8-24.5)	.8
Days with invasive MV	7 (3-14)	4 (2-13)	.001
Days without invasive MV	3 (0-6)	5 (3-8.5)	<.001
Days of bed rest	14 (8-22)	9 (6-17)	<.001
MRC	42 (32-51)	47.5 (36-55.2)	<.001
Patients with ICUAW	347 (76.6)	96 (50.8)	<.001
Death	156 (34.4)	5 (2.6)	<.001

Note: Categorical variables are expressed as frequency and percentage (n [%]), and quantitative variables with non-normal distribution as median (interquartile range).

Abbreviations: APACHE II, acute physiology and chronic health evaluation II; BMI, body mass index; ICUAW, intensive care unit acquired-muscle weakness; IMS, ICU mobility scale; MRC, Medical Research Council scale (MRC sum-score); MV, mechanical ventilation; SOFA, sequential organ failure assessment.

[a]APACHE II (assessed in 226 patients without active mobility and 95 with active mobility); SOFA (assessed in 95 patients without active mobility and 31 with active mobility).

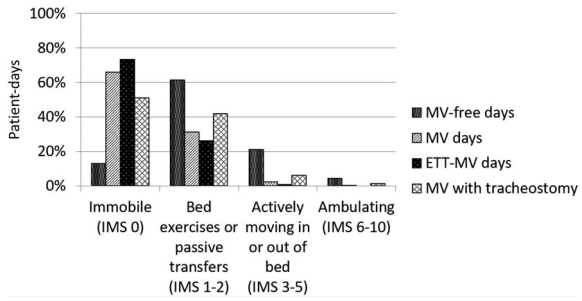

FIGURE 2 Level of patient mobility according to type of airway management. Mechanical ventilation (MV)-free days (3276 patient-days): days without mechanical ventilation. MV days (6770 patient-days): days with mechanical ventilation. Endotracheal tube (ETT)-MV days (4557 patient-days): days of mechanical ventilation with endotracheal tube. MV with tracheostomy (2213 patient-days): days of mechanical ventilation with a tracheostomy tube

4.6 | Ethical and research approvals

The study was approved by the Ethics and Clinical Research Committees of the participating centres. During the first 48 hours of admission, patients who were alert, cooperative, and oriented—or otherwise their next of kin—were asked to give their informed consent. If informed consent was obtained, data collection commenced on day 3 of the ICU stay.

5 | RESULTS

We analysed the data of 642 patients, corresponding to 10 046 patient-days and 80 ICUs, which represent 35% of the 228 ICUs in Spain, according to the database of the Spanish Society for Intensive Care Nurses. Figure S1 shows a flow diagram with the patients' movement through the study.

TABLE 3 Level of mobility and clinical characteristics of the patients

	ICU day 3 n = 642 patient-days	ICU days 4-7 n = 2385 patient-days	ICU day ≥8 n = 7019 patient-days
Immobile (IMS = 0)	504 (78.5)	1423 (59.7)	2962 (42.2)
Bed exercises or passive transfers (IMS = 1-2)	133 (20.7)	790 (33.1)	3203 (45.6)
Actively moving in or out of bed (IMS = 3-5)	3 (0.5)	157 (6.6)	699 (9.9)
Ambulating (IMS = 6-10)	2 (0.3)	15 (0.6)	155 (2.2)
Airway management			
MV with ETT	603 (93.9)	1719 (72.1)	2235 (31.8)
MV with tracheostomy	14 (2.2)	83 (3.5)	2116 (30.1)
MV-free	25 (3.9)	583 (24.4)	2668 (38.1)
Sedation level			
Deep sedation (RASS −5 to −3)	262 (40.8)	732 (30.7)	1165 (16.6)
Moderate sedation (RASS −2 to 0)	133 (20.7)	554 (23.2)	2322 (33.1)
Anxious-agitated (RASS +1 to +4)	19 (2.9)	130 (5.4)	371 (5.3)
RASS data missing	228 (35.5)	967 (40.5)	3157 (45)
% moderate sedation[a]	75.6 ± 30.4	80.8 ± 27.7	88.7 ± 22.7
Without MRC assessment			
Asleep	388 (60.4)	1351 (56.6)	2257 (32.1)
Unable to follow commands	60 (9.3)	295 (12.4)	1189 (16.9)
With MRC assessment[b]			
Without ICUAW (MRC >48)	49 (55.7)	92 (50.8)	206 (37)
With ICUAW	39 (44.3)	89 (49.2)	351 (63)
MRC 36-47	24 (27.3)	56 (30.9)	185 (33.2)
MRC <36	15 (17)	33 (18.2)	166 (29.8)
Pain assessment	278 (43.3)	977 (41)	2580 (36.7)
Presence of delirium			
According to nurse in charge	19 (2.9)	111 (4.6)	239 (3.4)
According to CAM-ICU	2 (0.3)	20 (0.8)	87 (1.2)
Need for restraint	168 (26.2)	504 (21.1)	1089 (15.5)
CRRT	97 (15.1)	323 (13.5)	711 (10.1)
Hemodynamic instability (vasoactive drugs[c])			
Without drugs	263 (41)	1443 (60.5)	5288 (75.3)
1 drug	304 (47.3)	790 (33.1)	1573 (22.4)
2 drugs	64 (10)	125 (5.2)	144 (2)
3 drugs	11 (1.7)	25 (1)	14 (0.2)
Respiratory instability			
FiO_2	49 ± 18.4	45.8 ± 18.1	42.5 ± 17.4
FiO_2 >60	101 (71.1)	321 (13.4)	659 (9.4)
PaO_2/FiO_2 ratio	213.4 ± 96.1	219 ± 98.6	226.6 ± 103.2
PEEP	7.6 ± 2.9	7.5 ± 2.9	7.1 ± 2.4
PEEP ≥10	159 (24.8)	440 (18.4)	801 (11.4)

Note: Evolution during ICU stay. Categorical variables are expressed as frequency and percentage (n [%]) and quantitative variables with normal distribution as mean and SD.

Abbreviations: CAM-ICU, confusion assessment method for the intensive care unit; CRRT, continuous renal replacement therapy; ETT, endotracheal tube; FiO_2, fraction of inspired oxygen; MRC, Medical Research Council scale (MRC sum-score); MV, mechanical ventilation; PaO_2, partial pressure of oxygen; PEEP, positive end-expiratory pressure; RASS, Richmond Agitation Sedation Scale.

[a]Percentage of moderate sedation: number of RASS scores ranging from −2 to 0 out of the total RASS assessments per day. N is 243, 889 and 2698 for each period, respectively.

[b]MRC sum-score assessment was feasible on 88, 181, and 557 patient-days for each period, respectively.

[c]Vasoactive drugs: dopamine, dobutamine, noradrenaline, epinephrine, milrinone, and levosimendan.

TABLE 4 ICU characteristics by level of mobility achieved by the patients during their ICU stay

	No active mobility (IMS <4) N = 453 patients	Active mobility (IMS ≥4) N = 189 patients	*P* value
ICU type			
Cardiothoracic	8 (1.8)	25 (13.2)	<.001
Coronary care	9 (2)	6 (3.2)	.4
Medical	30 (6.6)	7 (3.7)	.2
Mixed	355 (784)	140 (74.1)	.2
Surgical	27 (6)	10 (5.3)	.8
Trauma	24 (5.3)	1 (0.5)	.002
ICU bed numbers			
<8	17 (3.8)	7 (3.7)	1
8-14	248 (54.7)	118 (62.4)	.08
15-24	131 (28.9)	40 (21.2)	.04
>24	57 (12.6)	24 (12.7)	1
Nurse-patient ratio			
1:2	203 (44.8)	105 (55.6)	.01
1:3	96 (21.2)	27 (14.3)	.05
1:4	8 (1.8)	9 (4.8)	.05
Shift-dependent	60 (13.2)	9 (4.8)	.001
Patient-dependent	86 (19)	39 (20.6)	.7
Physiotherapy hours per day available in the ICU[a]	4 (2-8)	5 (3-9)	.003
Mobilization prescribed by			
RM specialist	233 (73.7)	104 (67.5)	.4
ICU physician	79 (25)	49 (31.8)	.02
Physiotherapist	4 (1.3)	1 (0.6)	1
Percentage of invasive MV usage in the ICU[b]	34.8 (22.5-44.2)	40.8 (25.7-46.4)	.02
ABCDEF bundle[c]			
Analgesia and sedation algorithms	95 (21)	48 (25.4)	.2
Daily interruption of sedation	62 (13.7)	24 (12.7)	.8
Delirium prevention	30 (6.6)	24 (12.7)	.02
Delirium management	39 (8.6)	20 (10.6)	.4
Early mobilization	32 (7.1)	22 (11.6)	.06
Sleep promotion	73 (16.1)	39 (20.6)	.2
Family engagement	106 (23.4)	29 (15.3)	.02

Note: Categorical variables are expressed as frequency and percentage (n [%]), and quantitative variables with non-normal distribution as median (interquartile range).

Abbreviations: ICU, intensive care unit; IMS, ICU mobility scale; MV, mechanical ventilation; RM, rehabilitation medicine.

[a]Hours of physiotherapist in the unit: total hours that the ICU has a physiotherapist present per day. Scheduled hours and the mean annual additional hours from referrals were included.

[b]Invasive MV usage formula: number of patients receiving invasive mechanical ventilation divided by the total patients in the ICU during the study period, multiplied by 100.

[c]Analgesia and sedation algorithms applied (target sedation, monitoring frequency and scale, physician- or nurse-led drug titration); daily interruption of sedation applied (delirium prevention protocol applied) (frequency of evaluation and reorientation measures); delirium management protocol applied (decrease in deliriogenic and antipsychotic drugs); early mobilization protocol applied (on days 2-5 of ICU stay); sleep promotion protocol applied (environmental control measures and sleep hygiene strategies); family engagement and empowerment strategies applied (flexible, extended visiting hours).

5.1 | Patient characteristics

The sample included medical, surgical, and trauma patients (62.1%, 32.4%, and 5.5%, respectively). Thirty-two percent were female, median age was 65 years (IQR 54-74), mean BMI was 26.9 ± 4.3, and median Charlson index was 4 (IQR 2-6). As a result of variations in practice, severity of illness scores were available only for a subset of patients. The median APACHE available for 321 patients (50%) was 21 (IQR 17-27), while the median SOFA score available for 126 patients (19.6%) was 9 (IQR 7-12).

Concerning ICU type, most patients were admitted to a mixed medical-surgical-trauma ICU (495 out of 642 patients). The patient populations were similar in all ICUs, except in medical ICUs (where patients were older and had multi-morbidities) and trauma ICUs (younger patients, more independent pre-admission, with fewer serious illnesses and almost no comorbidities).

5.2 | Primary outcome: Mobility

Patients were immobile (IMS = 0) on 48.7% of the 10 046 patient-days, they received bed exercises or passive transfers (IMS = 1-2) on 41.1% of days, actively moved in or out of bed (IMS = 3-5) on 8.6%, and ambulated (IMS = 6-10) on 1.7% of the total patient-days. Change in mobility level by ICU day is shown in Table 1. Immobility was gradually reduced, more through increased bed exercises and passive transfers rather than actively moving in or out of bed.

A total of 189 patients (29.4%) achieved active mobility, which was initially observed on day 9 (IQR 6-17.5) of the ICU stay (Figure 1), mainly in younger patients recovering from cardiovascular surgery, who had a lower BMI and needed fewer days of bed rest and invasive MV. The percentage of patients who developed ICUAW or died was much lower in patients who achieved active mobility than those who did not (Table 2).

Concerning ventilation modes, immobility was generalized during MV patient-days (65.9%), especially among patients with ETT (73.2% of patient-days) than those with tracheostomy (50.9%). Immobility was found to decrease to 13% on MV-free patient-days (Figure 2).

Bed exercises or passive transfers were observed on 31.2% of invasive MV patient-days, increasing to 41.8% in tracheostomy patient-days, and 61.5% in MV-free patient-days. Actively moving in or out of bed was found in just 2.4% of invasive MV patient-days, 6.1% of tracheostomy patient-days, and 21.2% of MV-free patient-days. Ambulating was observed only on 4.3% of MV-free patient days (Figure 2).

Analysing the level of mobility by days of ICU stay (Table 3), immobility was 59.7% from days 4 to 7 and decreased to 42.2% from day 8 onwards. This improvement was mainly noted among patients able to perform bed exercises or passive transfers (45.6%). Patient-days with immobility decreased as the percentage of ETT-MV declined. By contrast, actively moving in or out of bed showed only a small increase (Table 3).

5.3 | Secondary outcome: Human resources

A nurse-patient ratio of 1:2 was associated more strongly with patients with active mobility versus no active mobility (55.6% vs 44.8%, $P = .01$), as was the nurse-patient ratio of 1:4 (4.8% vs 1.8%, $P = .05$) (Table 4). However, the shift-dependent nurse-patient ratio and the ratio of 1:3 were associated with no active mobility. Patients in ICUs with a nurse-patient ratio of 1:2 or 1:3 had worse disease severity (median APACHE 22 [IQR 17-29]) than patients in ICUs with a nurse-patient ratio of 1:4 (14.5 [IQR 9-22]), $P = .014$.

Patients achieving active mobility were in ICUs with more physiotherapist hours than patients who did not (5^{3-9} vs $4,^{2-8}$ $P = .003$). Mobility was also enhanced on ICUs where the physician could call in the physiotherapist without referring patients first to a rehabilitation medicine specialist.

5.4 | Secondary outcome: ABCDEF bundle guidelines

ICUs with delirium prevention protocols had more patients with active mobility compared with ICUs without these protocols (12.7% vs 6.6%, $P = .02$). Conversely, family engagement was not associated with active mobility compared with no active mobility (15.3% vs 23.4%, $P = .02$) (Table 4).

Although deep sedation decreased during the ICU stay, only 33.1% of patient-days were in the optimum range of sedation (RASS −2 to 0) after the first week, when ICUAW reached a peak (63%). Pain assessment was omitted on nearly half the patient-days. Moreover, the incidence of delirium was low, as defined by the nurse in charge (2.9% on ICU day 3 and 4.6% on ICU days 4-7) (Table 3).

For ICU days 3 to 5, we selected the following covariates for the logistic regression model: age, gender, BMI, MRC feasibility, MRC sum-score (baseline MRC), presence of delirium, CRRT, low mobilization-related drugs, vasoactive agents, ETT, FiO_2, nurse-patient ratio, physiotherapist availability, percentage of invasive MV usage, and bundle dose. These variables are described in the footnote for Table S5.

The multivariate analysis for this period (AUC-ROC: 0.7887, Figure S2) showed that active mobility (IMS ≥4) was more likely to be achieved with a nurse-patient ratio of 1:4 (OR 3.7 95% CI [1.2-11.2]), a high MRC sum-score (OR 1.05 95% CI [1.04-1.06]), and presence of delirium (OR 1.01 95% CI [1.00-1.02]). By contrast, mobility was hindered by a higher BMI (OR 0.92 95% CI [0.88-0.97]), a nurse-patient ratio of 1:3 (OR 0.54 95% CI [0.32-0.93]), or a shift-dependent nurse-patient ratio (OR 0.27 95% CI [0.12-0.62]).

6 | DISCUSSION

According to the literature, our study is the fourth multi-centre study with a national scope conducted in the past decade in Europe and the first in our country to assess the level of mobility of ICU patients.[12,13,27]

Our results show that patients with ETT are not actively mobile. In countries such as the United States, Switzerland, and Germany, patients are mobilized even if they have ETTs.[11-13] This trend is more marked in more recent than in older studies.[8] The percentage of active mobilization in our study was significantly lower than in other countries with reference to patient-days of invasive MV with tracheostomy (7.4% vs 19.5% in Australia,[8] 25% in Brazil,[10] 39% in Germany,[13] and 58% in Switzerland[12]) and for MV-free patient-days (25.5% vs 50% in Switzerland,[12] 50% in Brazil,[10] 53% in Germany,[13] 56% in USA,[11] and 66.4% in Australia[8]).

This low level of mobilization among patients with ETT may be explained by nurses' concerns for device integrity, as identified in a recent study by Hermes[28] and by low physiotherapist availability in the ICU.

By level of mobilization, passive transfer to a chair was more common than out-of-bed mobility, and this finding was not reported in the other studies. According to the Hermes study,[28] one explanation could be that nurses encourage patients to sit in a chair together with their family, while physiotherapists—who have a reduced presence in our setting—focus more on marching on the spot for strength and functionality.

While some authors link the presence of physiotherapists to more active mobilization,[11,16] others do not.[12,29] There is a lower presence of physiotherapists in our ICUs (5[2-9] hours/week) compared with countries where physiotherapists are part of the ICU staff[7,10,27] and this could explain why passive mobilization is predominant. According to Garzón-Serrano,[30] McWilliams,[15] Rebel,[23] and Hermes,[28] higher levels of patient mobilization are achieved when physiotherapists lead mobilization decisions. Garzón-Serrano[30] suggests that physiotherapists, "with their specific knowledge of neurologic and musculoskeletal conditions, might be more focused on how to advance individual patients with mobilization therapy".[30] Therefore, physiotherapists should guide mobilization, taking into account patients' muscular strength and exercise tolerance, especially in the presence of a low MRC sum-score.[15]

The presence of ICUAW emerged as a barrier to active mobilization, which corroborates the results reported by Tipping[20] but contrasts those of Berney's study,[8] which found that under half (44.4%) of the patients with ICUAW were not mobilized, compared with three-quarters (76.6%) in our study. Furthermore, we found that a higher MRC score was associated with more mobilization, in line with a systematic review by Parry et al[6] A study in Australia[31] found that patient weakness and loss of muscle mass are perceived as barriers to mobilization, and yet it is patients with precisely these problems who would benefit most from EM. Therefore, a multidisciplinary decision-making process involving nurses, physicians, and physiotherapists is fundamental.[20,29,31]

Active mobility was initially observed in our study on day 9 [IQR 6-17], compared with day 5[3-9] in one study in Australia[9] and on days 3 to 4 in another.[7] This late mobilization could be explained by a lack of protocols promoting EM practices. Only 12.5% of the ICUs in our study applied these protocols,[32] compared with 24 to 30% in the international study by Bakhru[16] and 45% in a study in Brazil.[10] Late mobilization could also be explained by the presence of two common barriers to EM, which are deep sedation[7,27,28] and concerns regarding haemodynamic and respiratory instability.[6,12,28]

Boehm[33] showed that as nurses' workloads increase, adherence to the ABCDEF bundle decreases substantially, and specifically, adherence to EM is affected worst, mainly because ABCDEF protocols reduce patient-days with deep sedation.[34] In Australia,[7] 30% of patients were found to be too sedated for mobilization on ICU day 3, and indeed in our study, this figure was 40.8%. As reported by Marra,[35] the implementation of sedation guidelines with nurse-driven algorithms is very important, because being conscious and cooperative at the beginning of the ICU stay is independently associated with active mobility.

Delirium prevention protocols, which include non-pharmacological strategies to promote sleep, have been shown to be effective in promoting active mobility. In our study, the onset of delirium in the first 5 days of ICU stay was associated with higher mobility.

Regarding safety criteria for active mobilization, in Berney's study,[8] of the patients who were classified as safe according to Hodgson's expert consensus criteria[36] (i.e. FiO_2 under 60%) 80% were actively mobilized. In our study, although 86.6% of the patient-days were within the range accepted as safe on ICU days 4 to 7, only 8.1% were actively mobilized.

Given that there is no current consensus about vasoactive drug levels and safe mobilization,[36] we understand that vasoactive therapy could be a barrier to mobilization. However, when analysing the 1443 patient-days without vasoactive agents on ICU days 4 to 7, only 10.7% were actively mobilized, in line with a recent study by Nickels et al[37] Conversely, Rebel et al[23] reported active mobilization on 37.5% of all vasoactive days.

In one recent study,[38] one of the top five barriers to EM was inappropriate nurse-patient ratio. In another, the second barrier identified was lack of nurses.[28] According to Bakhru et al,[16] more patients per nurse implied less mobilization, but our multivariate analysis showed the opposite. Greater mobility was achieved when the nurse-patient ratio was 1:4, in the context of intermediate ICUs where patients are less critically ill. Poorer mobility occurred in ICUs with ratios of 1:3, because one of the barriers to EM is fear of mobilization as a result of haemodynamic or respiratory instability, and this situation is more common among these critically ill patients.

Therefore, our findings corroborate those in recent studies by Sibilla[12] and Nickels,[37] reporting that ratios of 1:4 are common where patients are less critically ill or likely to recover faster and mobilization is therefore much easier.

Finally, although studies by Jolley[11] and Brock[22] found no association between patient weight and mobility, we found an association between lower BMI and higher active mobility.

7 | LIMITATIONS

The study sample was heterogeneous in that just under a third were surgical patients and only a small proportion (5.5%) were trauma patients. The small representation of trauma and neurology patients can be explained by the inclusion criteria. Delirium was diagnosed only subjectively, because the CAM-ICU scale is not frequently used in our setting.[32] When the diagnosis of delirium is based on the charge nurse's subjective assessment, only hyperactive delirium is likely to be detected. Therefore, delirium was clearly underdiagnosed. It should be noted that hypoactive delirium remains unrecognized in 66% to 84% of hospitalized patients.[35] To standardize the data collection in the database, we decided to consider the APACHE II scale only, because it is the most widely used scale.[26] This lack of data meant we were unable to include severity scores as covariates in the multivariate analysis. Finally, another limitation was that ICUs were not questioned about the availability of mobilization aids.

8 | IMPLICATIONS AND RECOMMENDATIONS FOR PRACTICE

An increased presence of physiotherapists on the ICU would improve mobilization levels, and facilitate mobilization in patients with ICUAW.

Instead of calculating nurse-patient ratios according to severity criteria, they should be based on nursing interventions, for

example, by applying the Nursing Activities Score, a scoring system to quantify the need of nursing care in ICUs, assigning a score per patient based on nursing tasks performed, and weighted by the time spent on each task. Adjusting ratios this way would achieve a wider application of the ABCDEF bundle, resulting in more awake, cooperative patients, improved pain assessment, and increased active mobilization.

9 | CONCLUSIONS

Immobility was prevalent on ETT-MV patient-days, whereas passive mobilization was prevalent on tracheostomy-MV and MV-free days. These low levels of mobility were observed even when patients met the safety criteria for active out-of-bed mobilization. A high MRC sum-score and presence of delirium during the first days in the ICU are protective factors of mobilization. A nurse-patient ratio of 1:4 shows a stronger association with active mobility because these patients are more stable.

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AUTHOR CONTRIBUTIONS

Marta Raurell-Torredà, Susana Arias-Rivera, Joan Daniel Martí, María Jesús Frade-Mera, Ignacio Zaragoza-García, Elisabet Gallart, Tamara Raquel Velasco-Sanz, Alicia San José Arribas and Eva Blazquez Martínez: Made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; Marta Raurell-Torredà, Susana Arias-Rivera, Joan Daniel Martí and Ignacio Zaragoza-García: Involved in drafting the manuscript or revising it critically for important intellectual content; Marta Raurell-Torredà, Susana Arias-Rivera, Joan Daniel Martí, María Jesús Frade-Mera, Ignacio Zaragoza-García, Elisabet Gallart-Vivé, Tamara Raquel Velasco-Sanz, Alicia San José Arribas, Eva Blazquez Martínez and MOviPre group: Given final approval of the version to be published. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content. Marta Raurell-Torredà, Susana Arias-Rivera and Ignacio Zaragoza-García agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ETHICS STATEMENT

The research meets all ethical requirements. The research has been reviewed by the ethics committees of the health centres involved.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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