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Predicting patient acuity according to their main problem

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Abstract

Aim: To assess the ability of the patient main problem to predict acuity in adults admitted to hospital wards and step-down units.

Background: Acuity refers to the categorization of patients based on their required nursing intensity. The relationship between acuity and nurses' clinical judgment on the patient problems, including their prioritization, is an underexplored issue.

Method: Cross-sectional, multi-centre study in a sample of 200,000 adults. Multivariate analysis of main problems potentially associated with acuity levels higher than acute was performed. Distribution of patients and outcome differences among acuity clusters were evaluated.

Results: The main problems identified are strongly associated with patient acuity. The model exhibits remarkable ability to predict acuity (AUC, 0.814; 95% CI, 0.81–0.816). Most patients (64.8%) match higher than acute categories. Significant differences in terms of mortality, hospital readmission and other outcomes are observed ($p < .005$).

Conclusion: The patient main problem predicts acuity. Most inpatients require more intensive than acute nursing care and their outcomes are adversely affected.

Implications for nursing management: Prospective measurement of acuity, considering nurses' clinical judgments on the patient main problem, is feasible and may contribute to support nurse management workforce planning and staffing decision-making, and to optimize patients, nurses and organizational outcomes.

KEYWORDS

acuity, clinical judgment, nursing intensity, patient classification systems, priority setting

1 | BACKGROUND

Nursing patient classification systems (PCS) have been employed in relation to nursing staff allocation efforts, budgeting, productivity and workload measurements.

Concepts related to PCS have been used interchangeably over time. Nursing workload refers to time and effort needed to accomplish both direct and indirect patient care, as well as nonpatient care activities (Swiger, Vance, & Patrician, 2016); nursing intensity embeds direct and indirect patient-related nursing care (Liljamo,

Kinnunen, Ohtonen, & Saranto, 2017), whilst patient acuity implies the categorization of patients based on their nursing care needs (Alghamdi, 2016) to determine their required nursing intensity, in terms of nursing hours per patient day (NHPPD).

A widely used PCS is the *All Patient Refined Diagnosis-related Groups* (APR-DRGs) that cluster hospital discharged patients into groups of medical conditions and procedures, and subclassifies them into four categories of severity and risk of mortality, from low to extreme (Averill et al., 2003); however, its usefulness to determine nursing care requirements or patient acuity remains unclear.

Regardless their design, either prototype—considering only selected relevant nursing tasks—or factor type—including a comprehensive list of nursing procedures—most of nursing PCS are based on interventions scores that may be explanatory of nursing workload, but they are not predictive of acuity or required nursing intensity according to the patient needs (Paulsen, 2018). In addition, front-line and head nurses perceive that workload is more influenced by patient characteristics, status or progress than by activity or tasks. Understanding patient status is essential in bedside decision-making, and it includes data collection, cues capture, critical thinking and clinical judgment, considering the probable course of the patient (Manetti, 2019). In this sense, the relationship between patient acuity and nurses' clinical judgment is still underexplored.

Despite its conceptual ambiguity, clinical judgment is considered synonymous with decision-making (Nibbelink & Brewer, 2018) and for long, nurses' clinical judgments on patient problems have been represented by nursing diagnoses (ND) (Juvé-Udina, 2013).

Recently, ND have been studied in relation to hospital length of stay using the NANDA International Classification (D'Agostino et al., 2019) or transfer to ICU and in-hospital mortality employing the ATIC terminology (Juvé-Udina et al., 2017); however, existing PCS do not consider nurses' clinical judgments on patient problems and their prioritization, although prioritizing impacts nursing workload (Swiger et al., 2016).

In this context, bedside priority setting implies the arrangement of problems to set a preferential order guiding the provision of interventions, to meet the expected outcomes. Thus, prioritization of the patient problems should lead to the identification of a primary diagnosis and other secondary ones. In this sense, the main diagnosis embeds the clinical judgment on the patient problem that generates the greatest need of nursing care in terms of immediacy of its management, care intensity or complexity (Juvé-Udina, 2013).

Nevertheless, whilst the need to develop and implement new predictive models that allow real-time measurements of patient acuity mix is stressed (Welton, 2017), it is still unknown whether patient acuity could be predicted weighting their main problem (MP).

The primary aim of this study is to assess the ability of the patient main problem to predict acuity in adults admitted to hospital wards and step-down units.

The secondary aims are to identify the distribution of acuity according to a PCS based on the MP weights and to evaluate whether differences exist in patient outcomes in terms of mortality, transfer to ICU, hospital readmission and three selected nursing-sensitive adverse events: hospital-acquired pressure injuries, falls and venous access-associated phlebitis.

2 | METHODS

2.1 | Design, setting and participants

This descriptive, observational, cross-sectional, retrospective, multicentre study was conducted in 118 adult wards and 15 step-down units, from eight public hospitals: three large, tertiary, metropolitan facilities (500–1,000 beds), three university hospitals (200–500 beds) and two community centres (100–200 beds). Average nurse per patient ratio in these floors is 1:10.5 (6–16) and 1:4 (3–6) in step-down units.

Nurses in these facilities use the ATIC terminology (Appendix 1), employ the same electronic health record (EHR) system and share reason for admission-based standardized care plans (SCP) that each nurse may adjust to the patient needs according to their assessment and judgment.

The study was intended to consecutively include the whole adult inpatient population admitted during 2016 and 2017. This represented a sample estimation of 200,000 patients. Critical care, maternal-child and paediatric patients were excluded.

2.2 | Data collection

The institutional research ethics committee approved the study. Data were gleaned blinded according to the current European regulations on data protection. Ethical standards related to data confidentially (access to records, data encryption and archiving) were complied with throughout the research process (European Commission, 2018).

Patients MP and outcomes data were blindly retrieved from the EHR. APR-DRG severity and risk of mortality data were gleaned from the hospitals minimum data set. A consecutive ID number was assigned to each patient data set.

MP weights were calculated applying the formula $\sum$[(% severity) (% risk of mortality)], considering all adults with the same MP identified in their care plan.

Mean weight variability of each MP was categorized in three groups: low (<5%), moderate (5%–10%) and high (>10%). To estimate the distribution of acuity, a PCS containing ten clusters, 40 subgroups and their equivalence to NHPPD was used (Appendix 2). The initial capacity of the MP weights to discriminate requirements of nursing intensity was categorized into excellent (>90%), very good (80%–90%), good (70%–80%), sufficient (60%–70%), low (50%–60%) and not useful (<50).

2.3 | Data analysis

Descriptive statistics were employed to analyse sample characteristics, continuous variables and categorical data. Pearson's

variation coefficient was used to estimate MP mean weight variability. Univariate analysis was used to assess MP initial discriminatory capacity, expressed in likelihood percentage.

To assess the ability of the MP weights to predict patient acuity, a logistic regression model was used. All potential explanatory variables included in the multivariate analyses were subjected to a correlation matrix for analysis collinearity. Results were reported as odds ratio (OR) at 95% confidence intervals (CI). The goodness of fit of the logistic model was evaluated by the Hosmer-Lemeshow test, and the discriminatory power was assessed by the area under the receiver operating characteristics (ROC) curve.

Significant differences among nursing intensity clusters and patient outcomes were detected using the chi-square test or Fisher's exact test for categorical variables. For continuous variables, Student's *t* test or Mann–Whitney *U* test was employed, depending on the results of the Kolmogorov-Smirnov normality test. *p* values less than .05 were considered statistically significant. All reported *p* values are 2-tailed.

The statistical analyses were performed using version 24.0 of SPSS package (IBM Chicago).

3 | RESULTS

The study considered 199,761 patients: 10,467 cases were excluded from the final analysis due to the absence of a care plan, no identification of the MP or not reaching 30 cases (5.2%), whereas 5,617 cases presented missed data or duplicates (2.8%).

The final analyses included 183,677 inpatients: 92.6% admitted in wards and 7.4% in step-down units; 56.1% were male patients, and their mean age was 68.8 years. Average number of problems e-charted in their care plans was 5.1 (range 2–11; 73% risk problems). The proportion of patients with minor or moderate APR-DRG severity and risk of mortality was 76.3% and 82.3%, respectively (Table 1).

TABLE 1 Baseline sample characteristics

	Study population	
	n = 183,677	
Characteristic	***N***	**%**
Age ≥75 years	58,005	31.6
Age (years)_median (IQR)	67	53–78
Male sex	102,764	55.9
Medical ward	96,058	52.3
Psychiatric ward	608	0.3
Step-down unit	13.582	7.4
Unscheduled admission	101,749	55.4
Length of stay_median (IQR)	4	2–8
Continuity of care (discharged to another facility)	7,330	4.0
Reason for admission		
Cardiocirculatory	30,336	16.5
Infectious	27,208	14.8
General surgery	20,766	11.3
Trauma and orthopaedics	19,951	10.8
Digestive, liver and pancreatic	19,790	10.7
Nervous system	15,472	8.4
Kidney and urinary tract	13,959	7.6
Respiratory	10,971	6.0
Reproductive	8,257	4.5
Head, neck and maxillofacial	5,501	3.0
Metabolic, nutritional and endocrinology	3,064	1.7
Haematopoiesis, blood and immunologic	2,705	1.5
Psychiatric, mental health and addictions	1,192	0.6
Skin and burns	907	0.5
Eyes	857	0.5
Other	2,741	1.5
Severity (APR-GRD 3–4)	43,557	23.7
Risk of mortality (APR-GRD 3–4)	32,558	17.7
Severity or risk of mortality (APR-GRD 3–4)	48,069	26.2

Abbreviations: IQR, interquartile range; APR-DRG, all patient refined diagnosis-related groups.

3.1 | Discriminatory ability of the main problem to predict acuity

The 183,677 MP considered in the final analysis represent 77 primary diagnostic concepts. Their weights and correspondence to each acuity cluster are detailed in Table 2. Most MP identified exhibit low or moderate mean weight variability (77.1%).

Univariate analysis showed 85.8% of the MP discriminate patients' requirements of nursing care intensity higher than acute, with excellent (46.7%), very good (23.3%), good (11.6%) and sufficient (5.1%) capacity. Within the acute cluster, five MP initially displayed eventual discriminatory capacity (Table 3).

A first multivariate analysis proved predictive ability of the MP in the intensification and upper clusters and confirmed that, four of those five MP that previously proved capacity exhibit sufficient predictive ability, suggesting they should be considered in the final model. The goodness of fit of this first model was 1, and the area under the ROC curve was 0.812 (95% CI, 0.809–0.815).

Final multivariate analysis findings indicated that there exists a strong association between the MP identified and nursing intensity requirements: their odds ratios are higher than 1, none of the 95% confidence intervals include 1 and most *p* values are <.001 (Table 4). No indication of collinearity between the variables that remained in the final model was found. The goodness of fit of the model was 1, and the area under the ROC curve was 0.814 (95% CI, 0.811–0.816) (Figure 1).

TABLE 2 Main problems weights, variability and correspondence to acuity clusters

Main problem	*N*	Weight	*SD*	CI	PVC (%)	VAR	Acuity cluster
Post-ICU syndrome	81	716	13.65	2.95	1.89	Low	Superintensive
Risk of multiorgan failure	229	661	35.46	4.5	5.63	Moderate	Intensive
Risk of organ graft rejection	134	625	20.94	3.45	3.42	Low	Intensive
Agony	592	607	8.17	0.65	1.35	Low	Intensive
Risk of cardiac tamponade	49	567	20.68	5.79	3.65	Low	Preintensive
Risk of disuse syndrome	1,044	554	46.05	2.77	7.84	Moderate	Preintensive
Risk of cardiogenic shock	330	549	4.87	0.51	0.88	Low	Preintensive
Risk of neurotoxicity recurrence/progression	205	540	52.89	7.1	9.05	Moderate	Preintensive
Risk of ventricular arrhythmia	51	538	6.08	1.65	1.13	Low	Preintensive
Risk of respiratory distress	5,177	532	22.55	0.6	4.34	Low	Preintensive
Risk of hepatorenal syndrome	602	524	27.7	2.18	5.17	Moderate	Preintensive
Risk of encephalopathy recurrence/progression	511	520	12.3	1.05	2.36	Low	Preintensive
Risk of cardiorenal syndrome	81	507	13.06	2.81	2.57	Low	Preintensive
Risk of acute pulmonary oedema	5,326	505	24.74	0.65	4.77	Low	Preintensive
Risk of septic shock	1,950	500	33.75	1.47	6.44	Moderate	Intermediate
Risk of thromboembolism	190	498	13.5	1.9	2.69	Low	Intermediate
Risk of hypervolaemia	501	486	14.1	1.22	2.96	Low	Intermediate
Risk of acidosis/alkalosis	1,354	484	29.3	1.54	5.84	Moderate	Intermediate
Risk of acute deterioration	964	482	1.57	0.09	0.32	Low	Intermediate
Risk of autonomic dysreflexia	283	474	34.75	3.93	7.3	Moderate	Intermediate
Risk of thromboembolism recurrence/progression	933	469	28.78	1.82	6.02	Moderate	Intermediate
Risk of chest tamponade	600	463	7.88	0.62	1.7	Low	Intermediate
Risk of neurogenic shock	48	455	36.16	9.73	7.94	Moderate	Intermediate
Risk of sepsis	20,433	453	45.58	0.61	12.31	High	Intermediate
Risk of cachectic syndrome recurrence/progression	112	450	8.83	1.61	1.96	Low	Intermediate
Risk of uraemic syndrome	123	449	31.06	5.36	6.97	Moderate	Intermediate
Risk of hypovolemic shock	610	447	19.04	1.41	4.24	Low	Intermediate
Risk of delirium recurrence/progression	476	439	19.14	1.68	4.37	Low	Intermediate
Risk of brain vasospasm	600	437	15.36	1.21	3.5	Low	Intermediate
Risk of hemodynamic instability	589	436	1.77	0.14	0.41	Low	Intermediate
Risk of alkalosis	215	424	6.13	0.81	1.44	Low	Intermediate
Risk of hypoxaemia recurrence/progression	1,426	421	25.6	1.3	5.97	Moderate	Intermediate
Risk of brain ischaemia/haemorrhage recurrence/progression	6,621	418	37.18	0.88	8.11	Moderate	Intermediate
Risk of hyper/hypovolaemia	897	417	45.8	2.96	10.28	High	Intermediate
Risk of systemic inflammatory response syndrome	4,392	415	32.86	0.95	7.82	Moderate	Intermediate
Risk of low cardiac output syndrome	4,734	407	42.42	1.19	10.84	High	Intermediate
Risk of hypovolaemia recurrence/progression	2,280	404	24.32	0.98	5.9	Moderate	Intermediate
Uncontrolled chronic pain	472	404	1.6	0.14	0.4	Low	Intermediate
Risk of abdomen compartment syndrome	351	394	25	2.57	6.3	Moderate	Intensification
Risk of suicidal intentionality recurrence/progression	39	390	43.72	13.38	11.31	High	Intensification
Risk of liver failure	1,376	389	39.79	2.07	10.35	High	Intensification
Risk of multiorgan toxicity	542	382	16.66	1.31	4.35	Low	Intensification
Risk of ischaemia recurrence/progression	1,101	380	15.85	0.92	4.15	Low	Intensification
Risk of hyperkalaemia	40	380	5.05	1.57	1.33	Low	Intensification

(Continues)

TABLE 2 (Continued)

Main problem	*N*	Weight	*SD*	CI	PVC (%)	VAR	Acuity cluster
Risk of effusion recurrence/progression	565	373	21.94	1.75	5.9	Moderate	Intensification
Risk of myocardial ischaemia recurrence/progression	7,205	371	2.56	0.05	0.69	Low	Intensification
Risk of hypovolaemia	17,605	359	38.01	0.55	11.01	High	Intensification
Risk of increased intracranial pressure	3,495	343	41.11	1.34	11.13	High	Intensification
Risk of biphasic anaphylaxis	33	336	9.72	3.18	2.89	Low	Intensification
Risk of deliberated self-harm	194	335	1.14	0.15	0.34	Low	Intensification
Risk of peritonitis	2,010	334	5.03	0.22	1.51	Low	Intensification
Risk of neurological deterioration	2,882	331	55.75	1.99	14.41	High	Intensification
Risk of airway obstruction	209	330	53.73	7.22	15.15	High	Intensification
Risk of ischaemia/haemorrhage	3,114	324	30.15	1.04	8.88	Moderate	Intensification
Risk of neurotoxicity	131	324	20.91	3.51	6.5	Moderate	Intensification
Risk of myocardial ischaemia	1,297	323	8.33	0.44	2.58	Low	Intensification
Risk of compartment syndrome	338	318	3.27	0.34	1.03	Low	Intensification
Risk of effusion	199	318	2.34	0.33	0.73	Low	Intensification
Risk of hypoxaemia	3,885	315	55.35	1.71	15.57	High	Intensification
Risk of complicated functional recovery	51	311	11.07	2.95	3.55	Low	Intensification
Risk of hyper/hypoglycaemia	52	310	20.41	5.12	6.55	Moderate	Intensification
Risk of haemorrhage recurrence/progression	1,015	301	32.59	1.97	11.66	High	Intensification
Risk of delusion recurrence/progression	302	300	16.98	1.88	5.64	Moderate	Acute
Risk of infection recurrence/progression	5,155	299	39.35	1.05	13.29	High	Acute
Risk of nutritional deficit recurrence/progression	59	298	2.28	0.58	0.76	Low	Acute
Risk of pancreatitis	814	298	0.08	0.01	0.03	Low	Acute
Risk of hyperadrenergic syndrome	83	296	40.59	8.68	13.32	High	Acute
Risk of sensory-motor deficit	840	292	18.95	1.26	6.34	Moderate	Acute
Risk of arrhythmia recurrence/progression	2,442	287	34.75	1.36	12.67	High	Acute
Risk of anxiety-depression syndrome	515	283	7.91	0.67	2.76	Low	Acute
Risk of haemorrhage	4,382	275	45.53	1.32	18.03	High	Acute
Risk of decreased intracranial pressure	218	269	13.74	1.8	5.15	Moderate	Acute
Activity intolerance	81	258	27.32	5.8	10.61	High	Acute
Risk of infection	913	257	32.15	2.03	11.84	High	Acute
Risk of postoperative haemorrhage	51,803	255	25.12	0.21	9.95	Moderate	Acute
Risk of hypocalcaemia	1,113	243	5.55	0.32	2.28	Low	Acute
Risk of postoperative infection	2,013	235	14.47	0.62	6.15	Moderate	Acute
TOTAL	183,677						

Abbreviations: *SD*, standard deviation; CI, 95% confidence interval; PVC, Pearson's variation coefficient; VAR, main problem mean weight variability.

3.2 | Distribution of acuity

According to this model, 35.1% of the studied patients are classified in the acute cluster. Most patients fall into the intensification (29.4%) or intermediate (27.7%) categories, which are equivalent to 3.5–5 and 5.5–7 required NHPPD, respectively, whilst around 8% of patients need preintensive, intensive or superintensive care, corresponding to 7.5 to 14 required NHPPD (Table 5). This implies that almost two thirds of the adult inpatient population (64.8%) need more intensive than acute nursing care, equivalent to an average required nursing intensity of 5.6 NHPPD or a 1:4.2 mean nurse per patient ratio. Similar values are found when excluding those patients in step-down units. Considering only ward patients, 63.5% require more intensive than acute care: 7.7% preintensive, 25.5% intermediate, 29.8% intensification and 0.5% intensive or superintensive nursing care, whilst 36.5% are classified in the acute category.

3.3 | Patient outcomes

Observed patient outcomes show statistically significant differences among the acuity clusters in terms of adverse events,

TABLE 3 Initial discriminatory capacity of the main problems

Main problem	*N*	% patients APR-DRG 3–4	% Likelihood	Predictive capacity	Acuity cluster
Post-ICU syndrome	81	97.53	99.85	Excellent	Superintensive
Risk of multiorgan failure	229	90.39	99.36	Excellent	Intensive
Risk of organ graft rejection	134	85.07	98.94	Excellent	Intensive
Agony	592	83.95	98.85	Excellent	Intensive
Risk of ventricular arrhythmia	51	82.35	98.71	Excellent	Preintensive
Risk of cardiac tamponade	49	79.59	98.46	Excellent	Preintensive
Risk of cardiogenic shock	330	77.88	98.30	Excellent	Preintensive
Risk of disuse syndrome	1,044	73.18	97.82	Excellent	Preintensive
Risk of respiratory distress	5,177	72.51	97.75	Excellent	Preintensive
Risk of cardiorenal syndrome	81	70.37	97.50	Excellent	Preintensive
Risk of neurotoxicity recurrence/progression	205	69.76	97.43	Excellent	Preintensive
Risk of hepatorenal syndrome	602	69.27	97.37	Excellent	Preintensive
Risk of encephalopathy recurrence/progression	511	69.08	97.35	Excellent	Preintensive
Risk of acidosis/alkalosis	1,354	68.61	97.29	Excellent	Intermediate
Risk of hypervolaemia	501	67.07	97.10	Excellent	Intermediate
Risk of acute pulmonary oedema	5,326	61.12	96.27	Excellent	Preintensive
Risk of autonomic dysreflexia	283	60.42	96.17	Excellent	Intermediate
Risk of thromboembolism	190	60	96.10	Excellent	Intermediate
Risk of septic shock	1,950	59.49	96.02	Excellent	Intermediate
Risk of haemodynamic instability	589	56.37	95.50	Excellent	Intermediate
Risk of acute deterioration	964	55.08	95.28	Excellent	Intermediate
Risk of neurogenic shock	48	54.17	95.11	Excellent	Intermediate
Risk of brain vasospasm	600	51.83	94.65	Excellent	Intermediate
Risk of chest tamponade	600	51.17	94.51	Excellent	Intermediate
Risk of thromboembolism recurrence/progression	933	50.38	94.35	Excellent	Intermediate
Risk of sepsis	20,433	49.14	94.08	Excellent	Intermediate
Risk of hypovolemic shock	610	48.03	93.83	Excellent	Intermediate
Risk of cachectic syndrome recurrence/progression	112	47.32	93.66	Excellent	Intermediate
Risk of hypoxaemia recurrence/progression	1,426	46.42	93.44	Excellent	Intermediate
Risk of alkalosis	215	45.58	93.23	Excellent	Intermediate
Risk of uraemic syndrome	123	43.9	92.79	Excellent	Intermediate
Risk of systemic inflammatory response syndrome	4,392	40.78	91.88	Excellent	Intermediate
Risk of delirium recurrence/progression	476	39.5	91.47	Excellent	Intermediate
Risk of hypovolaemia recurrence/progression	2,280	38.46	91.13	Excellent	Intermediate
Risk of hyper/hypovolaemia	897	35.56	90.08	Excellent	Intermediate
Uncontrolled chronic pain	472	35.38	90	Excellent	Intermediate
Risk of abdomen compartment syndrome	351	35.04	89.87	Very good	Intensification
Risk of effusion recurrence/progression	565	33.45	89.21	Very good	Intensification
Risk of brain ischaemia/haemorrhage recurrence/progression	6,621	33.26	89.12	Very good	Intermediate
Risk of low cardiac output syndrome	4,734	32.81	88.93	Very good	Intermediate
Risk of ischaemia recurrence/progression	1,101	32.43	88.75	Very good	Intensification
Risk of liver failure	1,376	31.83	88.48	Very good	Intensification
Risk of suicidal intentionality recurrence/progression	39	30.77	87.97	Very good	Intensification

(Continues)

TABLE 3 (Continued)

Main problem	*N*	% patients APR-DRG 3–4	% Likelihood	Predictive capacity	Acuity cluster
Risk of hypovolaemia	17,605	26.1	85.32	Very good	Intensification
Risk of increased intracranial pressure	3,495	25.18	84.69	Very good	Intensification
Risk of airway obstruction	209	24.88	84.50	Very good	Intensification
Risk of myocardial ischaemia recurrence/progression	7,205	24.09	83.92	Very good	Intensification
Risk of deliberated self-harm	194	23.71	83.63	Very good	Intensification
Risk of hyperkalaemia	40	22.5	82.67	Very good	Intensification
Risk of complicated functional recovery	51	21.57	81.88	Very good	Intensification
Risk of peritonitis	2,010	21.44	81.79	Very good	Intensification
Risk of biphasic anaphylaxis	33	21.21	81.58	Very good	Intensification
Risk of neurological deterioration	2,882	20.16	80.58	Very good	Intensification
Risk of neurotoxicity	131	19.85	80.28	Very good	Intensification
Risk of nutritional deficit recurrence/progression	59	15.25	77.19	Good	Acute
Risk of compartment syndrome	338	16.86	76.96	Good	Intensification
Risk of ischaemia/haemorrhage	3,114	16.28	76.19	Good	Intensification
Risk of hyper/hypoglycaemia	52	15.38	74.94	Good	Intensification
Risk of hypoxaemia	3,885	15.08	74.49	Good	Intensification
Risk of infection recurrence/progression	5,155	13.39	74.39	Good	Acute
Risk of myocardial ischaemia	1,297	14.03	72.83	Good	Intensification
Risk of multiorgan toxicity	542	13.47	71.91	Good	Intensification
Risk of effusion	199	13.07	71.18	Good	Intensification
Risk of haemorrhage recurrence/progression	1,015	11.72	68.55	Sufficient	Intensification
Risk of hyperadrenergic syndrome	83	9.64	66.73	Sufficient	Acute
Risk of pancreatitis	814	9.21	65.61	Sufficient	Acute
Risk of delusion recurrence/progression	302	8.28	62.92	Sufficient	Acute
Risk of haemorrhage	4,382	5.82	49.20	Not useful	Acute
Risk of anxiety-depression syndrome	515	5.44	47.37	Not useful	Acute
Risk of infection	913	5.15	45.95	Not useful	Acute
Activity intolerance	81	4.94	44.75	Not useful	Acute
Risk of postoperative haemorrhage	51,803	4.75	43.82	Not useful	Acute
Risk of postoperative infection	2,013	2.29	27.01	Not useful	Acute
Risk of hypocalcaemia	1,113	1.53	19.35	Not useful	Acute
Risk of sensory-motor deficit	840	13.21	19.22	Not useful	Acute
Risk of arrhythmia recurrence/progression	2,442	10.52	15.54	Not useful	Acute
Risk of decreased intracranial pressure	218	9.17	13.64	Not useful	Acute

Abbreviations: APR-DRG, all patient refined diagnosis-related groups.

hospital readmission, transfer to ICU and mortality ($p < .005$). In comparison with the acute group, outcome values are twofold to fivefold in the intensification category and most values almost twist again for intermediate care acuity group (Table 5). Adverse events display increasing trends in the upper clusters, whilst transfer to ICU decreases, except for those individuals in the superintensive group. When compared to patients classified as requiring acute intensity (0.2%), mortality increases sevenfold within the intensification cluster (1.5%), and up to 3.3% and 5.5% in the intermediate and preintensive categories, respectively (Table 5).

4 | DISCUSSION

4.1 | Discussion of the results

The primary finding of this study is that the MP are independent predictors of patient acuity. The area under the ROC curve (AUC) indicates a remarkable ability of the MP weight model to determine acuity, with an 81% chance to distinguish required nursing intensity among patients admitted in wards and step-down units. Acuity distribution shows most inpatients match acuity clusters higher than

TABLE 4 Final multivariate analysis and correspondence with the acuity patient classification system

Main problem	*N*	OR	CI	p value	Acuity cluster	Weight	NHPPD	Range
Post-ICU syndrome	81	649.51	159.58–264.66	<.001	Superintensive	716	14	14–23
Risk of multiorgan failure	229	154.72	99.58–240.39	<.001	Intensive	661	12	10–13
Risk of organ graft rejection	134	93.73	58.22–150.90	<.001	Intensive	625	10	10–13
Agony	592	86.03	68.92–107.38	<.001	Intensive	607	10	10–13
Risk of ventricular arrhythmia	51	76.74	37.33–157.75	<.001	Preintensive	538	8.25	7.5–10
Risk of cardiac tamponade	49	64.13	31.99–128.55	<.001	Preintensive	567	9	7.5–10
Risk of cardiogenic shock	330	57.89	44.55–75.22	<.001	Preintensive	549	8.25	7.5–10
Risk of disuse syndrome	1,044	44.87	38.98–51.64	<.001	Preintensive	554	9	7.5–10
Risk of respiratory distress	5,177	43.38	40.50–46.47	<.001	Preintensive	532	8.25	7.5–10
Risk of cardiorenal syndrome	81	39.05	24.21–62.99	<.001	Preintensive	507	7.5	7.5–10
Risk of neurotoxicity recurrence/ progression	205	37.93	28.10–51.18	<.001	Preintensive	540	8.25	7.5–10
Risk of hepatorenal syndrome	602	37.06	31.08–44.20	<.001	Preintensive	524	7.5	7.5–10
Risk of encephalopathy recurrence/ progression	511	36.74	30.37–44.44	<.001	Preintensive	520	7.5	7.5–10
Risk of acidosis/alkalosis	1,354	35.94	31.91–40.49	<.001	Intermediate	484	7	5.5–7
Risk of hypervolaemia	501	33.49	27.72–40.45	<.001	Intermediate	486	7	5.5–7
Risk of acute pulmonary oedema	5,326	25.84	24.25–27.54	<.001	Preintensive	505	7.5	7.5–10
Risk of autonomic dysreflexia	283	25.11	19.74–31.93	<.001	Intermediate	474	6.5	5.5–7
Risk of thromboembolism	190	24.67	18.42–33.03	<.001	Intermediate	498	7	5.5–7
Risk of septic shock	1,950	24.15	21.94–26.57	<.001	Intermediate	500	7	5.5–7
Risk of hemodynamic instability	589	21.24	18.00–25.08	<.001	Intermediate	436	6	5.5–7
Risk of acute deterioration	964	20.17	17.69–22.98	<.001	Intermediate	482	7	5.5–7
Risk of neurogenic shock	48	19.43	11.01–34.32	<.001	Intermediate	455	6.5	5.5–7
Risk of brain vasospasm	600	17.7	15.03–20.83	<.001	Intermediate	437	6	5.5–7
Risk of chest tamponade	600	17.23	14.64–20.28	<.001	Intermediate	463	6.5	5.5–7
Risk of thromboembolism recurrence/ progression	933	16.69	14.63–19.05	<.001	Intermediate	469	6.5	5.5–7
Risk of sepsis	20,433	15.89	15.24–16.57	<.001	Intermediate	453	6.5	5.5–7
Risk of hypovolemic shock	610	15.2	12.93–17.87	<.001	Intermediate	447	6	5.5–7
Risk of cachectic syndrome recurrence/ progression	112	14.77	10.18–21.43	<.001	Intermediate	450	6	5.5–7
Risk of hypoxaemia recurrence/ progression	1,426	14.25	12.78–15.89	<.001	Intermediate	421	5.5	5.5–7
Risk of alkalosis	215	13.77	10.51–18.05	<.001	Intermediate	424	5.5	5.5–7
Risk of uraemic syndrome	123	12.87	9.00–18.40	<.001	Intermediate	449	6	5.5–7
Risk of systemic inflammatory response syndrome	4,392	11.32	10.58–12.12	<.001	Intermediate	415	5.5	5.5–7
Risk of delirium recurrence/progression	476	10.73	8.91–12.93	<.001	Intermediate	439	6	5.5–7
Risk of hypovolaemia recurrence/ progression	2,280	10.28	9.39–11.25	<.001	Intermediate	404	5.5	5.5–7
Risk of hyper/hypovolaemia	897	9.08	7.89–10.44	<.001	Intermediate	417	5.5	5.5–7
Uncontrolled chronic pain	472	9	7.44–10.90	<.001	Intermediate	404	5.5	5.5–7
Risk of abdomen compartment syndrome	351	8.87	7.11–11.07	<.001	Intensification	394	5	3–5
Risk of effusion recurrence/progression	565	8.27	6.92–9.87	<.001	Intensification	373	4.5	3–5
Risk of brain ischaemia/haemorrhage recurrence/progression	6,621	8.19	7.72–8.70	<.001	Intermediate	418	5.5	5.5–7

(Continues)

TABLE 4 (Continued)

Main problem	*N*	OR	CI	p value	Acuity cluster	Weight	NHPPD	Range
Risk of low cardiac output syndrome	4,734	8.03	7.50–8.60	<.001	Intermediate	407	5.5	5.5–7
Risk of peripheral ischaemia recurrence/progression	1,101	7.89	6.93–8.99	<.001	Intensification	380	5	3.5–5
Risk of liver failure	1,376	7.68	6.83–8.64	<.001	Intensification	389	5	3.5–5
Risk of suicidal intentionality recurrence/progression	39	7.31	3.70–14.44	<.001	Intensification	390	5	3.5–5
Risk of hypovolaemia	17,605	5.81	5.55–6.08	<.001	Intensification	359	4.5	3.5–5
Risk of increased intracranial pressure	3,495	5.53	5.09–6.01	<.001	Intensification	343	4	3.5–5
Risk of airway obstruction	209	5.45	3.97–7.46	<.001	Intensification	330	4	3.5–5
Risk of myocardial ischaemia recurrence/progression	7,205	5.22	4.90–5.56	<.001	Intensification	371	4.5	3.5–5
Risk of deliberated self-harm	194	5.11	3.67–7.13	<.001	Intensification	335	4	3.5–5
Risk of hyperkalaemia	40	4.77	2.27–10.03	<.001	Intensification	380	5	3.5–5
Risk of complicated functional recovery	51	4.52	2.32–8.82	<.001	Intensification	335	4	3.5–5
Risk of peritonitis	2,010	4.49	4.02–5.02	<.001	Intensification	334	4	3.5–5
Risk of biphasic anaphylaxis	33	4.43	1.92–10.21	<.001	Intensification	336	4	3.5–5
Risk of neurological deterioration	2,882	4.15	3.77–4.57	<.001	Intensification	331	4	3.5–5
Risk of neurotoxicity	131	4.07	2.65–6.26	<.001	Intensification	324	3.5	3.5–5
Risk of compartment syndrome	338	3.34	2.51–4.44	<.001	Intensification	318	3.5	3.5–5
Risk of ischaemia/haemorrhage	3,114	3.2	2.89–3.54	<.001	Intensification	324	3.5	3.5–5
Risk of hyper/hypoglycaemia	52	2.99	1.41–6.35	.004	Intensification	310	3.5	3.5–5
Risk of hypoxaemia	3,885	2.92	2.66–3.21	<.001	Intensification	315	3.5	3.5–5
Risk of myocardial ischaemia	1,297	2.68	2.29–3.15	<.001	Intensification	323	3.5	3.5–5
Risk of multiorgan toxicity	542	2.56	2.00–3.28	<.001	Intensification	382	5	3.5–5
Risk of effusion	199	2.47	1.63–3.74	<.001	Intensification	318	3.5	3.5–5
Risk of haemorrhage recurrence/progression	1,015	2.18	1.80–2.65	<.001	Intensification	301	3.5	3.5–5
Risk of delusion recurrence/progression	302	1.69	1.12–2.55	.012	Intensification[b]	301[a]	3.5	3.5–5
Risk of infection recurrence/progression	5,155	2.90	2.66–3.17	<.001	Intensification[b]	301[a]	3.5	3.5–5
Risk of nutritional deficit recurrence/progression	59	3.38	1.66–6.88	.001	Intensification[b]	301[a]	3.5	3.5–5
Risk of pancreatitis	814	1.90	1.50–2.42	<.001	Intensification[b]	301[a]	3.5	3.5–5

Note: The goodness of fit of the model was 1 and the area under the ROC curve was 0.814 (95% confidence interval 0.811–0.816).
Abbreviations: OR, odds ratio; CI, 95% confidence interval; NHPPD, nursing hours per patient day.
[a]Final adjusted weight of the four MP initially located at the upper edge of the acute cluster that proved sufficient predictive ability.
[b]Mean weight and intensity cluster adjusted according to univariate and initial multivariate analysis results.

acute, and their outcomes in terms of nurse-sensitive outcomes worsen as acuity increases.

In the absence of similar studies, the result from a recent inquiry on the ability of the Oulu PCS scores and nursing notes to predict acuity was used for comparison (Kontio et al., 2014). Their model achieved a concordance index of 0.821 that may be interpreted as a refined AUC value, consistent with our findings.

Likewise, a recent systematic review identifies the need for refining workload measurements based on "*weighted patients according to their care loads*" (Wynendaele, Willems, & Trybou, 2019). In this study, the MP weights seem to be clinically meaningful, ranking problems such as post-ICU syndrome or risk of multiorgan failure first. This could suggest that the higher the medical intricacy, the greater the nursing intensity required; however, other MP at the top of the ranking dispel this misconception. This is the case for instance of patients diagnosed with agony, the struggle that precedes death in those states in which life is gradually extinguished. Intensive palliative care has been identified for ward patients at risk for dying soon who experience severe symptoms, reporting an average of 10.3 NHPPD (Fuly, Pires, Souza, Oliveira, & Padilha, 2016).

Regarding mental health MP, none is found within upper acuity groups. In the psychiatric population, factors, such as entrapment, history of self-harm or maladaptive personality traits, may play a

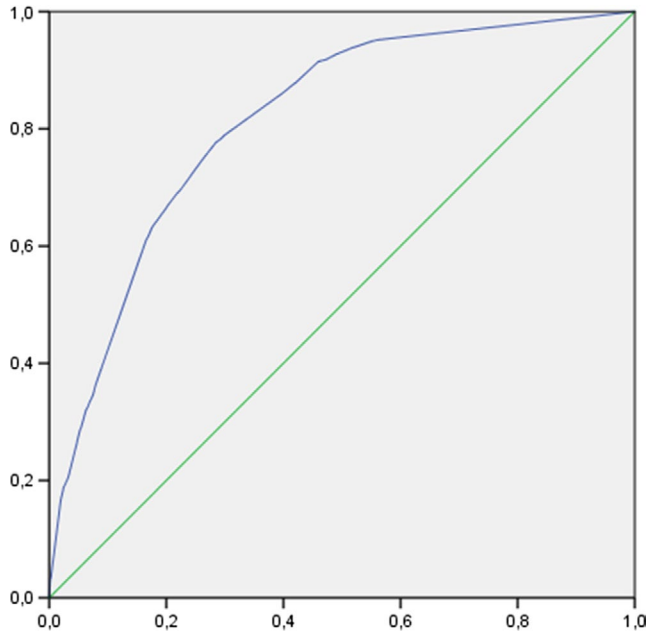

FIGURE 1 ROC curve of the model on the ability of the main problem to predict patient acuity [Colour figure can be viewed at wileyonlinelibrary.com]
X-axis_specificity Y-axis_sensitivity. Values: Goodness of fit of the model_1; Area under the ROC curve_0.814; Standard error_0.001; Asymptotic significance_0.000; 95% Confidence interval_0.811–0.816

role in acuity assessment. The need for further research in this area has recently been reported (Sousa & Seabra, 2018). Similarly, psycho-emotional and mental health impairments have been described as individual complexity sources (Adamuz et al., 2018), calling for deepening studies on the relationship between acuity and complexity.

According to the findings, 64.8% of the adult inpatient population needs more intensive than acute nursing care, with an average required nursing care intensity of 5.6 NHPPD. This finding aligns with nursing intensity identified in the study on staffing and mortality by Aiken et al. (2017), and are quite consistent with the allocation of an average NHPPD "*ranging from 3.5 to 7.5*" (Twigg & Duffield, 2009). The findings also positively contrast with the results of several studies measuring workload that reported a mean of six to twelve NHPPD in different hospital wards (Silva et al., 2015; Trepichio, Guirardello Ede, Duran, & Brito, 2013). Other inquiries concluded that workload in step-down units was similar to conventional ICUs (Amstrong et al., 2015; D'Orazio, Dragonetti, Finiguerra, & Simone, 2015).

Conversely, information volume has been assessed as a measure of care intensity. The relationship on the number of nursing notes and acuity has been explored (Liljamo, Kinnuen, & Saranto, 2018), and the number of ND has been analysed related to needed nursing intensity (Castellan, Sluga, Spina, & Sanson, 2016); however, a high number of ND might be reflecting poor prioritization and a linear decision-making process, in which each problem seems to be conceived independent from the others and the whole situation of the patient.

Nurses' priority setting of patient problems is based on urgency, clinical significance, potential harm, impact in daily living and patient perceptions of importance, but prioritization also depends on clinical expertise of registered nurses, time constraints, budget balance, professional values and organizational context (Skirbekk, Hem, & Nortvedt, 2018; Vryonides, Papastavrou, Charalambous, Androu, & Merkouris, 2015). In this sense, positive practice environments enhance nurse expertise to deliver high-quality nursing care and influence their decision-making and priority setting. Nurses' clinical judgments and patients care plans, essential concepts in this study, are factors considered in the evaluation of practice environments when using the Practice Environment Scale of the Nursing Work Index (Swiger et al., 2017).

In the context of this inquiry, reason for admission, population-based SCP are used to assure patient care quality and safety, and to ease nursing care provision and documentation. Population-based care models are oriented at improving health outcomes of different groups of individuals, and their approach emphasizes prevention and intervention at different echelons, implying the patient exists from the individual and family level, as groups or communities, to populations in themselves (Iseel & Bekemeier, 2010). Likewise, population-based SCP are a form of nursing structural capital, since they are knowledge shifted into information structures that nurses employ to support their clinical decision-making and planning (Covell & Sidani, 2013). The use of SCP could be considered a weakness, since it might influence the prioritization of the MP; however, nurses using them in practice may change any aspect of their content, to adjust SCP to each patient needs based on assessment data analysis (Castellà-Creus, Delgado-Hito, Andrés-Martinez, & Juvé-Udina, 2019). In fact, it is known that nurses' experience and their understanding of the patient status influence the use of SCP. Experienced nurses tend to favour their own expertise over information contained in a standard to guide their decision-making and properly individualize the SCP to the patient status and needs (Nibbelink & Brewer, 2018).

4.2 | Strengths and limitations

To the best of our knowledge, this is the first acuity PCS based on nurses' clinical judgment on patient problems and their prioritization.

The study presents those limitations implicitly embedded in a retrospective, cross-sectional, limited to a national level inquiry, whilst its multi-centre approach and large sample size are remarkable strengths.

Mean weight variability of the MP was low or moderate in most instances; however, in the absence of similar studies, the categorization of the PVC was just based on the authors' consensus. High mean heft variability could be related to nurses' limited knowledge on a selected problem screening or identification (i.e. risk of suicidal intentionality recurrence/progression) or difficulties identifying problems at the borderlines between two or more established entities

TABLE 5 Observed features and outcomes within each acuity cluster of the patient classification system

	Acute		Intensification		Intermediate		Preintensive		Intensive[a]		Superintensive	
	n = 64,403 (35.1)		*n* = 54,059 (29.4)		*n* = 50,803 (27.7)		*n* = 13,376 (7.3)		*n* = 363 (0.2)		*n* = 81 (0.04)	
Features and Outcomes	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Clinical characteristics												
Age (years). median (IQR)	62	48–73*	66	52–77*	71	58–81*	76	65–84*	65	54–77*	64	56–74
Age ≥75 years	13,400	20.8*	16,357	30.3*	20,458	40.3*	8,125	52.2*	105	28.9	16	19.8**
Male sex	32,147	49.9*	32,885	60.8*	29,428	57.9*	7,752	58*	215	59.2	59	72.8**
Severity or mortality risk (APR-GRD 3–4)	3,256	5.1*	11,850	21.9*	22,985	45.2*	9,081	67.9*	321	88.4*	79	97.5*
ICU admission	1,267	2*	3,560	6.6*	4,985	9.8*	781	5.8	221	60.9*	66	81.5*
LOS (days). median (IQR)	2	1–4*	5	3–8*	7	4–11*	7	5–12*	15	8–30*	62	33–90*
Continuity of care (another facility)	1,539	2.4*	1,720	3.2*	3,300	6.5*	726	5.4*	26	7.2**	17	21*
Outcomes												
Readmission (<31 days)	654	1*	2,497	4.6*	4,286	8.4*	1,491	11.1*	32	8.8**	1	1.2
Transfer to ICU	394	0.6*	842	1.6*	2,041	4*	201	1.3*	8	2.2	20	24.7*
Adverse event	1,932	3*	4,616	8.5*	6,526	12.8*	1,998	14.9*	61	16.8*	32	39.5*
Phlebitis	1,527	2.4*	3,321	6.1*	3,913	7.7*	1,018	7.6*	32	8.8**	11	13.6**
Pressure ulcer	160	0.2*	378	0.7*	814	1.6*	284	2.1*	12	3.3*	21	25.9*
Falls	173	0.3*	336	0.6*	557	1.1*	144	1.1*	2	0.6	4	4.9**
Deceased	150	0.2*	811	1.5*	1,695	3.3*	734	5.5*	21	5.8*	8	9.9*

Abbreviations: IQR, interquartile range; APR-GRD, all patient refined diagnosis-related group; ICU, intensive care unit; LOS, length of stay

[a]Excluded those patients with *Agony* as the main problem for its relationship with mortality and other outcomes.

*p value <0.001 (categorical variables were compared using the Fisher exact test and continuous variables using the Mann–Whitney test)

**p value >0.001 and <0.05 (categorical variables were compared using the Fisher exact test and continuous variables using the Mann–Whitney test)

(i.e. differentiation between risk of infection recurrence/progression from risk of sepsis), so further studies are needed to gain a better understanding on this issue since, as long as there exist multiple levels of nurses' clinical expertise, different degrees of situation awareness capacity and clinical judgment accuracy will co-exist (Nibbelink & Brewer, 2018).

In this study, the effect of patient secondary problems and individual complexity factors (Adamuz et al., 2018) were not controlled. To what extent these variables influence acuity at individual level is unknown, so additional studies are granted. In addition, because of its cross-sectional design, changes in patient status could not be considered. Nevertheless, the findings are consistent with the results of a longitudinal inquiry on patient acuity, based on nurses' clinical judgment that identified a subset of heart failure inpatients classified as requiring higher levels of nursing intensity in terms of NHPPD (Garcia, 2017).

On the other hand, in this investigation, patient outcomes in each acuity group were only analysed for observational purposes, so causal relationships cannot be proven. The findings indicate significant differences on major outcomes among the acuity clusters, suggesting a potential association that has to be demonstrated. Most outcomes p values are statistically significant, but it is acknowledged that p values are dependent on the sample size, so these findings should be interpreted with caution.

Additionally, the terminology used by nurses in this study is not as renowned as other nursing language systems, but it offers conceptual coverage for multiple cascade effect problems and for different types of nurses' clinical judgments (Juvé-Udina, 2013).

Thompson, Aitken, Doran, and Dowding (2013) classified four types of clinical judgments: those statements describing causality, the actually descriptive, the ones which are evaluative, considering changes in status from one point in time to another, and those predicting the likely course of a patient.

The results of our study suggest that only a few MP identified by nurses are descriptive. Most of them (94%) are risk problems that match predictive or combined type clinical judgments, such as risk of hemodynamic instability (predictive), risk of disuse syndrome (causal and predictive) or risk of peripheral ischaemia recurrence/progression (evaluative and predictive). These types of judgments arise from the combination of several sources of information, with initial and ongoing assessment data being pivotal. In this sense, the results of the present inquiry correspond almost inversely with the ones in a study on prevalent ND in the hospital ward setting using the NANDA-I Classification (D'Agostino et al., 2017), where most of them are actual, descriptive judgments, and only 15% are predictive. To some extent, this might suggest the influence of each language system used to represent nurses' clinical judgments on patient problems in the EHR.

4.3 | Implications for nursing management

A major objective for nurse managers is to strike the balance among nursing care quality, patient safety, practice environment, nursing workload and expenditure. Lack of consideration of patient problem prioritization is one of the factors that may impact quality, safety and workload measurement (Swiger et al., 2016).

Prioritization of nurses' clinical judgments is essential to identify relationships among problems and avoid severe consequences for patients. All patient needs should be considered, but addressing the MP may contribute to prevent or solve other secondary ones. This implies prioritizing problems contributing, causing or triggering other ones, mostly according to the severity of the patient conditions and their risk of death, both variables considered in the MP weights model presented, found to be predictive of acuity. Moreover, our results coincide to existing evidence on the identification of hospital wards no longer as conventional units, but areas with multiple patient acuity profiles, from acute to superintensive.

The PCS presented does not require the nurse to complete any additional data form to inform patient acuity, since the MP weights can be included as a field in the corresponding database table in any EHR system, for subsequent data mining, exploitation, use or reuse. Moreover, in terms of nursing international data exchange, comparison or benchmarking, given the different nursing and healthcare language systems used in the EHR around the world, concept mappings among terminologies could be employed to minimize the eventual gaps in acuity measurement (Bowles et al., 2013).

Although in this study patient acuity was not confronted to nursing intensity offered, the average nurse per patient ratio in this inquiry (1:10.5) is slightly lighter than the national ratio (1:12.9) and heavier than the European (1:9), according to the data reported in an international cross-sectional survey (Aiken et al., 2012). This might suggest a relevant implication for nursing and healthcare management, ethics and politics, since almost two thirds of adult inpatients might not be receiving the nursing care intensity they need. Nevertheless, further research is needed since average nurse per patient ratio methods may be useful to inform workload at aggregated level but they may result insufficient at unit and individual level (Paulsen, 2018; Welton, 2017).

Finally, the subservient position of nurses has been identified as the "*root cause of nurse staffing problems*" (van Oostveen, Mathijssen, & Vermeulen, 2015); however, it has been demonstrated that promoting favourable work environments is reasonably low-cost, creating added value for better patient outcomes (Aiken et al., 2018). The use of PCS based on nurses' clinical judgments may contribute to enhance professional autonomy and to promote less task-oriented and more patient-centred, supportive practice environments. Acknowledging its limitations, the PCS presented exhibits capacity to prospectively inform patient acuity, support workforce planning and staffing decision-making at hospital or unit level, estimate nursing costs and contribute to optimize patients, nurses and organizational outcomes.

5 | CONCLUSION

The patient main problem predicts patient acuity, suggesting this PCS is a useful tool to estimate nursing time requirements of adult patients admitted to hospital wards and step-down units.

The majority of adult ward inpatients are in need for more intensive than acute nursing care, and their outcomes in terms of mortality, transfer to ICU, hospital readmission, falls, pressure injuries and catheter-associated phlebitis are observed to be adversely affected, advancing that they are probably not receiving the nursing intensity required.

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AUTHOR CONTRIBUTION

Authors contributed equally to this work.

ETHICAL APPROVAL

An ethics application for the research project was submitted to the Bellvitge University Hospital Research Ethics Committee granting approval (PR 3851/18).

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