BMC Nursing

RESEARCH

Open Access

Impact of nurse staffing coverage and care complexity factors on health outcomes in hospitalized COVID-19 patients: a cross-sectional study

Jordi Adamuz[1,2,5*], Maribel González-Samartino[1,2,4,5], Emilio Jiménez-Martínez[2,3,5], Marta Tapia-Pérez[1,5], María-Magdalena López-Jiménez[1,2,5], Patricia Valero-Valdelvira[6], Esperanza Zuriguel-Pérez[7], Carmen Berbis-Morelló[8], Susana Asensio-Flores[4,5] and Maria-Eulàlia Juvé-Udina[5,9]

Abstract

Background Few studies have captured the impact of inadequate nurse staffing levels and broader health patient conditions in admitted patients during the COVID-19 pandemic. We aimed to determine the association between nurse staffing coverage, care complexity individual factors (CCIFs) and adverse events (AEs) in patients admitted with COVID-19.

Methods A multicentre cross-sectional study was conducted from March 1, 2020 to March 31, 2022 at eight public health hospitals in Spain. All patients with COVID-19 who were admitted to these hospitals were included. The main variables included AEs, nurse staffing coverage (as measured using the ATIC patient classification system) and CCIFs to evaluate broader patient health conditions. Adjusted logistic models were performed to identify associations with AEs, stratified by patients admitted to wards and hospitalized patients who required admission to intensive care units (ICUs).

Results A total of 11,968 hospitalized patients, 2,824 (23.6%) experienced AEs. Multivariate analysis showed that higher levels of nurse staffing coverage protected against AEs. Among patients admitted to acute wards, the independent risk factors for AEs included old age, haemodynamic instability, chronic disease, uncontrolled pain, urinary or faecal incontinence and mental status impairments. In addition to these factors, extreme weight, position impairment and communication disorders were factors associated with AEs in patients who required ICU admission.

Conclusions Nurse staffing coverage was a protective factor for AEs. Several CCIFs related to comorbidity/complications, developmental, and mental-cognitive domains were strongly associated with AEs. Therefore, ensuring safe nurse staffing levels could be improve patient outcomes.

Keywords Patient outcome assessment, Quality of health care, Risk factors, Nursing staff, Patient safety, COVID-19

*Correspondence:
Jordi Adamuz
jadamuz@bellvitgehospital.cat

Full list of author information is available at the end of the article

Background

There is abundant evidence that inadequate staffing is a chronic issue in the nursing profession, with significant safety consequences in hospitalized patients [1–3]. Such understaffing is likely to have been exacerbated by the COVID-19 pandemic due to additional pressures related to surging case numbers, restructuring of nursing staff and insufficient training of the health workforce [4, 5]. In this context, previous studies have shown that both personnel and expertise understaffing jointly shape near misses in COVID-19 patients, which are known to precede and contribute to accidents and injuries that impact patient safety [5–7]. In this sense, evidence shows that nurses' educational level is associated with adverse events (AEs) [8, 9]. Consequently, nurse staffing and other factors related to patient care complexity can have an impact on AEs [10, 11].

At the end of February 2020, Spain identified the first cases of a novel coronavirus, COVID-19. Within a few weeks, the epidemic escalated exponentially, straining and collapsing the health system in the affected areas [4]. In this context, previous studies have reported the occurrence of acute respiratory failure or acute respiratory distress syndrome, in 29–42% of COVID-19 patients during hospitalization [10, 12, 13]. Many clinical factors have been associated with AEs in hospitalized COVID-19 patients [14–18], but few studies have assessed other broader health determinants such as care complexity individual factors (CCIF) [10], nurse staffing, and patient acuity [6, 7].

Several patient classification systems have been developed to cluster patients according to their nursing care requirements [19, 20]. In recent years, the *Acute to intensive care* ATIC patient classification system has been validated [20], and it measures patient acuity based on the weight of the patient main problem identified in the nursing care plan, equivalent to required nursing hours per patient day. This system determines the nurse staffing coverage that reflects the balance between registered nurse hours required by each patient to meet their safety needs (patient acuity), and the available or real offered registered nurse hours to each patient [20, 21]. The validity study revealed notable predictive ability of this system for patient acuity [20]. It is implemented in managerial daily practice in the Catalan Institute of Health [22], the major public healthcare provider in Catalonia (Spain), and has been used in a previous inquiry to demonstrate the association of nurse staffing coverage and patient outcomes [23].

Furthermore, evidence shows that several complexity factors related to comorbidities, developmental, emotional, mental-cognitive and sociocultural were associated with AEs [10, 23, 24]. Although a prior study explored the association CCIF and health outcomes [10], the specific impact of nurse staffing coverage on AEs in hospitalized COVID-19 patients remains unclear.

Therefore, the aim of this study is to evaluate the association between nursing coverage and care complexity individual factors (CCIF) with adverse events (AEs) in patients admitted with COVID-19. By identifying how nurse staffing coverage and specific complexity factors contribute to AEs, this study can inform targeted nurse staffing strategies and ultimately enhance patient safety outcomes.

Methods

Setting and study design

A cross-sectional study was carried out at eight public hospitals in Spain from March 1, 2020 to March 31, 2022: three high-tech metropolitan centres and five other regional referral hospitals. These facilities account for more than 4,000 beds, 166 wards and step-down units, and 289,101 patient discharges over the two-year study period.

Participants

All adult patients with COVID-19 admitted in general wards or step-down units (intermediate care), with a nursing care plan charted in electronic health records, were consecutively included. Only patients directly admitted and discharged from ICU were excluded, because the main study variables were not contained in the nursing health records. Moreover, obstetrics, maternal-child, and paediatric patients were excluded. The study was intended to consecutively include all admitted patients meeting selection criteria.

For the purpose of this study, patients with COVID-19 were classified into the following two groups: those who had AEs occurring during hospitalization, and those who did not.

Ethical considerations

This study was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki. It was evaluated and approved by the Clinical Research Ethics Committee of the Bellvitge University Hospital (reference PR293/20), which also waived the requirement for informed consent due to retrospective nature of the study. All ethical and data protection protocols related to anonymity and data confidentiality (access to records, data encryption and archiving of information) were complied with throughout the study. All data were deidentified using a unique identification number.

Data collection

All data were collected retrospectively from the electronic health record system, the hospital minimum data set and the clinical data warehouse of the Catalan

Institute of Health. A unique identification number was used to link the data sets from these sources. Nursing staff data were obtained from human resources databases and ward structural assignment reports. Patient data were subsequently matched to nursing staff data, considering the type of unit and the time frame within which each patient received care.

Variables

The main study variables are AEs, registered nurse (RN) staffing coverage and care complexity individual factors.

Adverse events (AEs)

The AEs included hospital-acquired infections (HAIs) and potentially avoidable critical complications (ACCs) during hospitalization. HAIs reflected the number of episodes in which ward patients developed a catheter-related bloodstream infection, a urinary catheter-related infection, aspiration pneumonia and/or sepsis. ACCs reflected the number of episodes in which ward patients experienced a cardiac arrest, shock, thromboembolic event, acute respiratory failure, myocardial injury, liver injury and/or kidney failure (online supplemental material 1).

RN staffing coverage

RN staffing measures included: (i) RN hours required per patient day (rNHPPD), (ii) RN hours available per patient day (aNHPPD) and, (iii) nurse staffing coverage.

rNHPPD were determined based on the main nursing diagnoses identified in the nursing records using the ATIC patient classification system. This system divides patient acuity into ten categories of nursing intensity, equivalent to the required RN hours per patient day [20]. For this study, we calculated the average rNHPPD across the entire hospital stay.

aNHPPD were computed by dividing the available registered nurse hours by the total number of patients in each unit each day. Patient counts was aggregated by shift and day, according to the unit assignment reports, allowing us to derive the average aNHPPD.

Finally, we calculated the overall NHPPD balance, defined as the difference between aNHPPD and rNHPPD. The average of RN staffing coverage was defined as the proportion of registered nurse rNHPPD covered by the aNHPPD.

In the context of the study, all RN have university bachelor's degree as it is a legal requirement for RN practice. The study excluded nurse assistants or licensed practice nurses.

Care complexity individual factors

Care complexity individual factors (CCIFs) are a group of patient characteristics related to different health dimensions, that may complicate care delivery and contribute to adverse outcomes [24]. They are classified into five domains: (i) mental-cognitive, (ii) psycho-emotional, (iii) sociocultural, (iv) developmental, and (v) comorbidity/complications, as described in previous studies [25, 26]. Patients were considered to have CCIF if they presented at least one related defined characteristic according to previous inquires [10, 23, 24, 26]. CCIFs were collected from the nursing assessment e-charts as structured data based on the Architecture, Terminology, Interface, Knowledge (ATIC) terminology [27] (online supplemental material 2).

Other demographics and clinical variables

We also collected information regarding the demographic and clinical characteristics of the patients, age, sex, underlying disease, continuity of care (discharged to another facility), length of hospital stay and admission to acute wards or to intensive care (ICU) (patients who required admission to the ICU or a step-down unit at any time during hospitalization).

Facilities were classified into two categories: high-tech hospitals or other. High-tech hospitals were defined as referral university centres that provide tertiary care for either open-heart surgery or major organ transplants.

Finally, we also gathered patient acute deterioration risk data, using the VIDA score, which classifies patients into five groups: no risk (level 0), low risk (level 1), moderate risk (level 2), high risk (impending complication if not stabilized) (level 3), or manifested critical complication initial status (level 4). These data, based on a clinical algorithm, are automatically calculated and charted in the electronic health records, on the basis of patient progress data collected by the RN. Patient progress data refers to respiratory rate, oxygen saturation, body temperature, mental status (level of awareness; 1 = aware and orientated, > 1 = disturbed mental status), heart rate, and systolic and diastolic blood pressure. As in a previous inquiry, the VIDA score was categorized as: low risk (level 0), moderate risk (levels 1–2) or high risk (levels 3–4) [10].

Validity and reliability

The ATIC patient classification system measures patient acuity, thereby allowing the identification of the registered nurse hours required per patient day; it is routinely implemented within the Catalan Institute of Health [22], and its validity for predicting patient acuity has been confirmed [20]. CCIFs were collected using a classification developed by Juvé-Udina et al. (2010) through a participatory action research study involving more than 400 nurses from eight public hospitals. This classification has been used to explore associations between CCIFs and unfavourable patient outcomes, and its predictive capacity has been demonstrated [24, 26]. Finally, the VIDA early warning system, introduced in 2013 was developed via a multidisciplinary approach, is applied daily to guide clinical decision-making and has shown strong predictive ability for both in-hospital mortality and AEs [10].

Statistical analysis

Descriptive analysis of data using percentage frequencies, median and interquartile range was performed to determine demographic and clinical characteristics and patient outcomes. For categorical variables, a comparative analysis for detecting significant differences between groups was carried out using the chi-square test or Fisher's exact test. For continuous variables, the Student's t-test or Mann-Whitney U test was used depending on the results of the Kolmogorov-Smirnov normality test. Those CCIFs found charted in less than 30 patients were excluded for the analysis since they do not achieve the minimum statistical number, that is the point at which the central limit theorem begins to apply (online supplemental material 1).

To explore the association of risk factors with AEs and estimate de effect of some explanatory variables on selected health outcomes, multiple raw and sex/age-adjusted logistic models were performed. We used logistic regression model because the output of the sigmoid function considered AEs as a binary outcome (yes/no). The estimated odds ratios of the models are presented in a forest plot. To study the impact of nursing coverage on AEs, raw and adjusted multivariate logistic models were performed. We included all the most relevant basal characteristics and CCIFs that showed a significant difference in the previous logistic model. This analysis was adjusted by age, sex, whether or not the hospital was a high-tech hospital, and underlying disease. The estimated odds ratios of all the models are presented in tables. The analyses were conducted separately for patients admitted in acute settings only and for patients hospitalized in acute settings who required admission to intensive care units, given the different behaviours in these settings in terms of nursing coverage. To mitigate the impact of missing data we only included patients with a completed hospital minimum data set and with a nursing care plan registered in electronic health records. Final data set was carefully revised and analysed to ensure the internal validity of the study.

The conditions of application of the models were validated and 95% confidence intervals of the estimators were calculated whenever possible. All analyses were performed using the statistical package R version 4.1.0 (2021-05-18) for Windows.

Results

During the study period, 14,470 patients were admitted with COVID-19, of which 11,968 met the inclusion criteria (Fig. 1).

The demographic and clinical characteristics of the study populations are presented in Table 1. Of these patients, 67.8% were admitted to a high-tech hospital, and 29% required care in an ICU unit or step-down unit. High and moderate risk of acute deterioration were the most frequent outcome of the VIDA score (61.4% and 26.1%, respectively).

Regarding nurse staffing measures, the mean nurse staffing coverage achieved 41% of the required nurse staffing. Almost 85% of patients required intermediate care (5–7 rNHPPD, equivalent to 1:4 nurse-to-patient

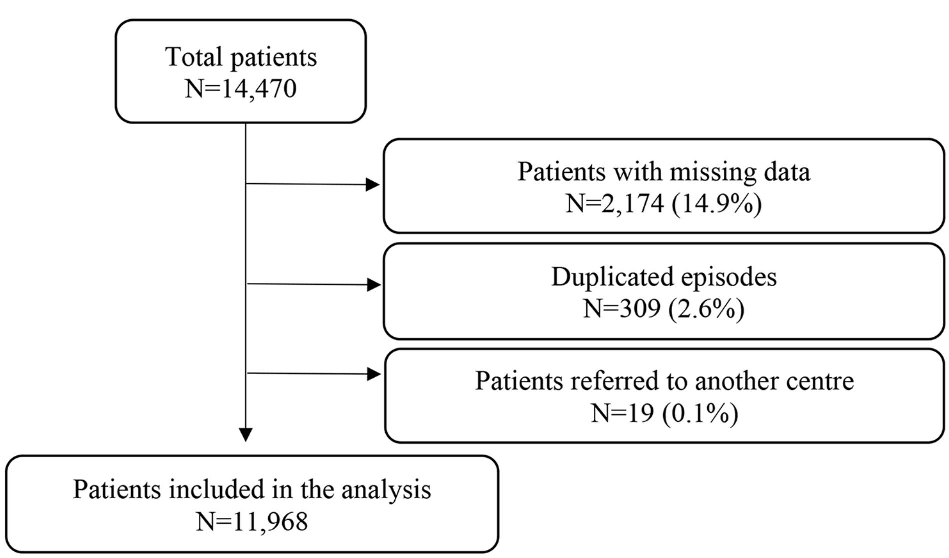

Fig. 1 Flowchart of the exclusion of patients from the analysis

Table 1 Baseline characteristics

Characteristics	Study population n = 11,968	
Demographic characteristics		
Age (years), mean (SD)	62.1	(16.6)
Female sex, N (%)	4,730	(39.5)
Clinical characteristics		
Length of stay, median (IQR)	8	(5–14)
Continuity of care (discharged to another facility), N (%)	1,513	(12.6)
High-tech hospital, N (%)	8,118	(67.8)
ICU unit, N (%)	3,473	(29.0)
Underlying disease, N (%)	7,064	(59.0)
Arterial hypertension or chronic heart failure, N (%)	4,628	(38.7)
Diabetes or chronic kidney disease, N (%)	3,050	(25.5)
Chronic respiratory disease, N (%)	1,432	(12.0)
Cancer, N (%)	749	(6.3)
Neurodegenerative disease, N (%)	122	(1.0)
Chronic liver disease, N (%)	125	(1.0)
Immunosuppression, N (%)	100	(0.8)
VIDA score		
Low risk (0), N (%)	1,495	(12.5)
Moderate risk (1–2), N (%)	7,354	(61.4)
High risk (3–4), N (%)	3,119	(26.1)

Abbreviations: SD, standard deviation; IQR, interquartile range; ICU, intensive care unit; VIDA, acute deterioration risk stratification

Table 2 Nurse staffing measures and CCIFs

Characteristics	Study population n = 11,968	
Staffing measures		
aNHPPD, median (IQR)	2.7	(2.5–3.1)
rNHPPD, median (IQR)	6.5	(6.5–7.0)
Intermediate (5–7 rNHPPD), N (%)	10,130	(84.6)
Preintensive or more (> 7 rNHPPD), N (%)	1,838	(15.4)
Balance, median (IQR)	-3.8	(-4.2 to -3.4)
Nurse staffing coverage, mean % (IQR)	40.9	(36.6–47.8)
Care complexity individual factors (CCIFs)		
Comorbidity/complications		
Haemodynamic instability, N (%)	10,325	(86.3)
Transmissible infection, N (%)	8,815	(73.6)
Chronic disease, N (%)	7,064	(59.0)
Uncontrolled pain, N (%)	2,466	(20.6)
Extreme weight, N (%)	1,100	(9.2)
Position impairment, N (%)	1,063	(8.9)
Urinary or faecal incontinence, N (%)	1.052	(8.8)
Anatomical and functional disorders, N (%)	554	(4.6)
Communication disorders, N (%)	278	(2.3)
Vascular fragility, N (%)	182	(1.5)
Immunosuppression, N (%)	100	(0.8)
Involuntary movements, N (%)	57	(0.5)
High risk of haemorrhage, N (%)	46	(0.4)
Developmental		
Old age (≥ 75 years), N (%)	3,036	(25.4)
Psycho-emotional		
Fear/anxiety, N (%)	856	(7.1)
Impaired adaptation, N (%)	844	(7.0)
Aggressive behaviour, N (%)	33	(0.3)
Mental-cognitive		
Mental status impairments, N (%)	2,425	(22.3)
Agitation, N (%)	123	(1.1)
Impaired cognitive functions, N (%)	45	(0.4)
Sociocultural		
Language barriers, N (%)	264	(2.2)
CCIFs, median (IQR)	4	(3–5)

Abbreviations: CCIFs, care complexity individual factors; IQR, interquartile range; aNHPPD, available RN hours per patient day; rNHPPD, required RN hours per patient day

ratio), and around 15% required preintensive or intensive care (>7 rNHPPD), according to the ATIC patient classification system. While aNHPPD was 2–3, equivalent to 1:8 nurse-to-patient ratio, in acute wards. Moreover, the main CCIFs were haemodynamic instability, transmissible infection requiring isolation precautions, and chronic disease (Table 2).

The frequency of AEs was 23.6%. Around 22% of patients experienced an avoidable critical complication (ACC) and 8% had a hospital-acquired infection (HAI). Further details on the ACC and HAI outcomes are provided in Table 3.

Analysis of risk factors associated with AEs

Comparing patients admitted to acute wards with those who were admitted to the ICU revealed that nurse staffing coverage was higher in the latter, and that regardless the unit of admission, lower nurse staffing coverage was found in patients who had an AE (Table 4). Figure 2 shows a forest plot of the raw and adjusted (according to age and sex) association of possible risk factors with AEs in patients admitted to wards and hospitalized patients who required admission to the ICU. Similar results were obtained in a raw and adjusted model. Regarding nursing staff measures, a higher number of rNHPPD was associated with AEs, and a higher number of aNHPPD and level of nurse staffing coverage protected against AEs. The CCIFs associated with AEs in patients admitted in acute settings were mental status impairments, chronic disease, old age, urinary or faecal incontinence, agitation, position impairment, communication disorders, haemodynamic instability, impaired cognitive function, anatomical disorders, uncontrolled pain, and extreme weight. Moderate and high risk of acute deterioration were also associated with AEs. Similar results were obtained in patients who required admission to ICU.

Table 3 Adverse events

Outcomes	All n = 11,968	
	N	(%)
Adverse events	2,824	(23.6)
HAI	953	(8.0)
HA urinary tract infection	578	(4.8)
Sepsis	273	(2.3)
Catheter-related bloodstream infection	144	(1.2)
Aspiration pneumonia	77	(0.6)
ACC	2,421	(22.2)
Renal insufficiency	1,046	(8.7)
Myocardial injury	786	(6.6)
Respiratory distress syndrome	705	(5.9)
Thrombotic event	433	(3.6)
Shock	48	(0.4)
Cardiac arrest	25	(0.2)
Liver injury	41	(0.3)

Abbreviations: HAI, hospital-acquired infection; ACC, avoidable critical complication

Multivariate association of nurse staffing coverage and CCIFs with AEs

The results of the multivariate analysis of nursing coverage measures and CCIFs are summarized in Table 5. Regarding patients admitted to general wards, after adjustment for potential confounders, the analysis showed that the level of nurse staffing coverage was a protective factor for AEs in COVID-19 ward inpatients. Furthermore, older age, chronic disease, haemodynamic instability, uncontrolled pain, urinary or faecal incontinence, and mental status disorders were risk factors associated with AEs. In addition of these findings, extreme weight, position impairment, and communication disorders were additional factors associated with AEs in patients who required admission to an ICU.

Accordingly, a higher level of nurse staffing coverage acts as a protective factor for all AEs. Several CCIFs related to comorbidity/complications, developmental, and mental-cognitive domains were risk factors remarkably associated to AEs.

Discussion

This study was aimed at demonstrating the association between nurse staffing coverage, CCIFs and AEs. A substantial number of patients admitted to acute wards with COVID-19 presented AEs during hospitalization. Multivariate analysis showed that risk factors associated with AEs in patients admitted to acute wards were old age, haemodynamic instability, chronic disease, uncontrolled pain, urinary or faecal incontinence and mental status impairment. Extreme weight, position impairment and communication disorders were additional factors associated with AEs in patients who required admission to the ICU. Conversely, higher levels of nurse staffing coverage protected against AEs. The identification of patient acuity and care complexity factors may contribute to prevent avoidable complications in COVID-19 patients.

Our findings are consistent with previous reports that found a similar frequency of AEs [12]. We found that the most relevant avoidable clinical complications were renal failure, myocardial injury, and respiratory distress syndrome. These results are consistent with previous studies that analysed these complications in patients admitted with COVID-19 [17, 28, 29]. Regarding HAIs, previous reports showed that the pandemic negatively impacted HAI rates and clusters of infections within hospitals [30]. This is consistent with our finding of a high incidence of hospital-acquired urinary tract infection, sepsis, and catheter-related bloodstream infection. Moreover, we observed that AEs had higher rates in hospitalized patients who were admitted to the ICU than in those admitted to acute wards (19.2 vs. 18.7 per 1,000 patient-days). In this regard, other studies showed that HAIs, cardiac arrest, and mortality rates were higher in patients admitted to the ICU [31, 32].

Our study shows that old age, haemodynamic instability, chronic disease, uncontrolled pain, urinary or faecal incontinence and mental status impairments are CCIFs associated with AEs in patients admitted with COVID-19. Regarding old age and chronic disease, other studies have shown that this virus causes worse outcomes and a higher mortality rate in the elderly and those with comorbidities such as hypertension, cardiovascular disease, diabetes, chronic respiratory disease, and chronic kidney disease [18, 33]. Older people admitted with COVID-19 present more geriatric syndromes including comorbidities, frailty, falls, cognitive impairment, and incontinence, which are associated with poor outcomes [34, 35]. Our findings are also consistent with another study demonstrating that pain is a persistent symptom in critical COVID-19 patients [36]. Concerning haemodynamic instability, it is important to note that it usually precedes the AE, such as in patients diagnosed with acute myocarditis [37]. Also, previous studies recommended the use of early warning scores to evaluate the acute deterioration risk, having demonstrated that these scores are good discriminators of death, ICU admission and AEs [10, 38]. Our study also showed the association of high and moderate risks of acute deterioration with AEs, measured using the VIDA score.

We found that extreme weight, position impairment and communication disorders were factors associated with AEs in patients who required admission to the ICU. These findings are consistent with other studies concluding that obesity is associated with admission

Table 4 Comparison between staffing measures and CCIFs with adverse events in patients admitted with COVID-19

Characteristics	Patients admitted to acute wards					Patients who required admission to ICU				
	Non-AE n = 7,258		AE n = 1,237		*p*-value	Non-AE N = 1,886		AE n = 1,587		*p*-value
	No.	(%)	No.	(%)		No.	(%)	No.	(%)	
Staffing measures										
aNHPPD, median (IQR)	2.7	(2.4–3.1)	2.6	(2.4–2.8)	< 0.001	3.1	(2.7–6.0)	3.0	(2.6–5.2)	< 0.001
rNHPPD					< 0.001					0.022
Intermediate (5–7 rNHPPD)	6,705	(92.4)	1,111	(89.8)		1,217	(64.5)	1,097	(69.1)	
Preintensive or more (> 7 rNHPPD)	553	(7.6)	126	(10.2)		669	(35.5)	490	(30.9)	
Balance, median (IQR)	-3.8	(-4.2 to -3.1)	-4.0	(-4.4 to -3.7)	< 0.001	-3.4	(-3.9 to -2.2)	-3.7	(-4.3 to -2.7)	< 0.001
Nurse staffing coverage, mean % (IQR)	40.9	(36.6 to 46.1)	39.5	(34 to 43.4)	< 0.001	47.8	(39.9–72.7)	42.9	(37.1–63.6)	< 0.001
Care complexity individual factors (CCIFs)										
Comorbidity/complications										
Haemodynamic instability	5,914	(81.5)	1,129	(91.3)	< 0.001	1,785	(94.6)	1,497	(94.3)	0.68
Transmissible infection	5,694	(78.4)	898	(72.6)	< 0.001	1,300	(68.9)	923	(58.2)	< 0.001
Chronic disease	4,112	(56.6)	995	(80.4)	< 0.001	994	(52.7)	963	(60.7)	< 0.001
Uncontrolled pain	1,342	(18.5)	329	(26.6)	< 0.001	356	(18.9)	439	(27.7)	< 0.001
Extreme weight	584	(8.1)	136	(11.1)	< 0.001	173	(9.2)	207	(13.0)	< 0.001
Position impairment	518	(7.1)	227	(18.3)	< 0.001	107	(5.7)	211	(13.3)	< 0.001
Urinary or faecal incontinence	595	(8.2)	257	(20.8)	< 0.001	80	(4.2)	120	(7.6)	< 0.001
Anatomical and functional disorders	293	(4.0)	103	(8.3)	< 0.001	60	(3.2)	98	(6.2)	< 0.001
Communication disorders	136	(1.9)	56	(4.5)	< 0.001	20	(1.1)	66	(4.2)	< 0.001
Vascular fragility	99	(1.4)	34	(2.7)	< 0.001	23	(1.2)	26	(1.6)	0.30
Immunosuppression					0.26	11	(0.6)	10	(0.6)	0.86
Involuntary movements	34	(0.5)	11	(0.9)	0.064	3	(0.2)	9	(0.6)	0.056
High risk of haemorrhage	26	(0.4)	6	(0.5)	0.50	8	(0.4)	6	(0.4)	0.83
Developmental										
Age (years), mean (SD)	61.7	(17.2)	72.0	(15.5)	< 0.001	58.0	(15.3)	61.6	(12.6)	< 0.001
Psycho-emotional										
Fear/anxiety	502	(6.9)	103	(8.3)	0.075	133	(7.0)	118	(7.4)	0.66
Impaired adaptation	507	(7.0)	98	(7.9)	0.24	125	(6.6)	114	(7.2)	0.52
Aggressive behaviour	20	(0.3)	4	(0.3)	0.77	3	(0.2)	6	(0.4)	0.22
Mental-cognitive										
Mental status impairments	1,136	(15.6)	550	(44.5)	< 0.001	274	(14.5)	465	(29.3)	< 0.001
Agitation	69	(0.9)	34	(2.7)	< 0.001	9	(0.5)	15	(0.9)	0.10
Impaired cognitive functions	28	(0.4)	11	(0.9)	0.019	3	(0.2)	3	(0.2)	0.83
Sociocultural										
Language barriers	154	(2.1)	19	(1.5)	0.18	54	(2.9)	37	(2.3)	0.33

Abbreviations: ICU, intensive care unit; AE, adverse event; OR, odds ratio; CI, confidence interval, SD, standard deviation; VIDA, acute deterioration risk stratification; aNHPPD, available RN hours per patient day; rNHPPD, required RN hours per patient day; IQR, interquartile range

to the ICU and in-hospital mortality [39, 40]. Previous studies have demonstrated a protective effect of physical activity on adverse COVID-19 outcomes [41]. This finding might be consistent with the observation that position impairments were associated with AEs in patients admitted to the ICU. Moreover, adults requiring intensive care treatment for critical COVID-19 infection can present with iatrogenic verbal communication impairments related to nervous system complications or laryngeal injuries [42]. Thus, our findings concur with previous reports in non-COVID-19 patients showing that CCIFs related to comorbidity/complications, developmental and mental-cognitive domains were risk factors associated with a selected AE [24]. However, other CCIF related with sociocultural domain (such as lack of caregiver support) was identified as a significant risk factor in previous studies [23, 24]. We did not include it because all patients admitted for COVID-19 had restricted visits. We identified an average of four CCIFs per patient, as in previous study in COVID-19 patients [10]. This average was lower in the pre-pandemic period [24]. These results

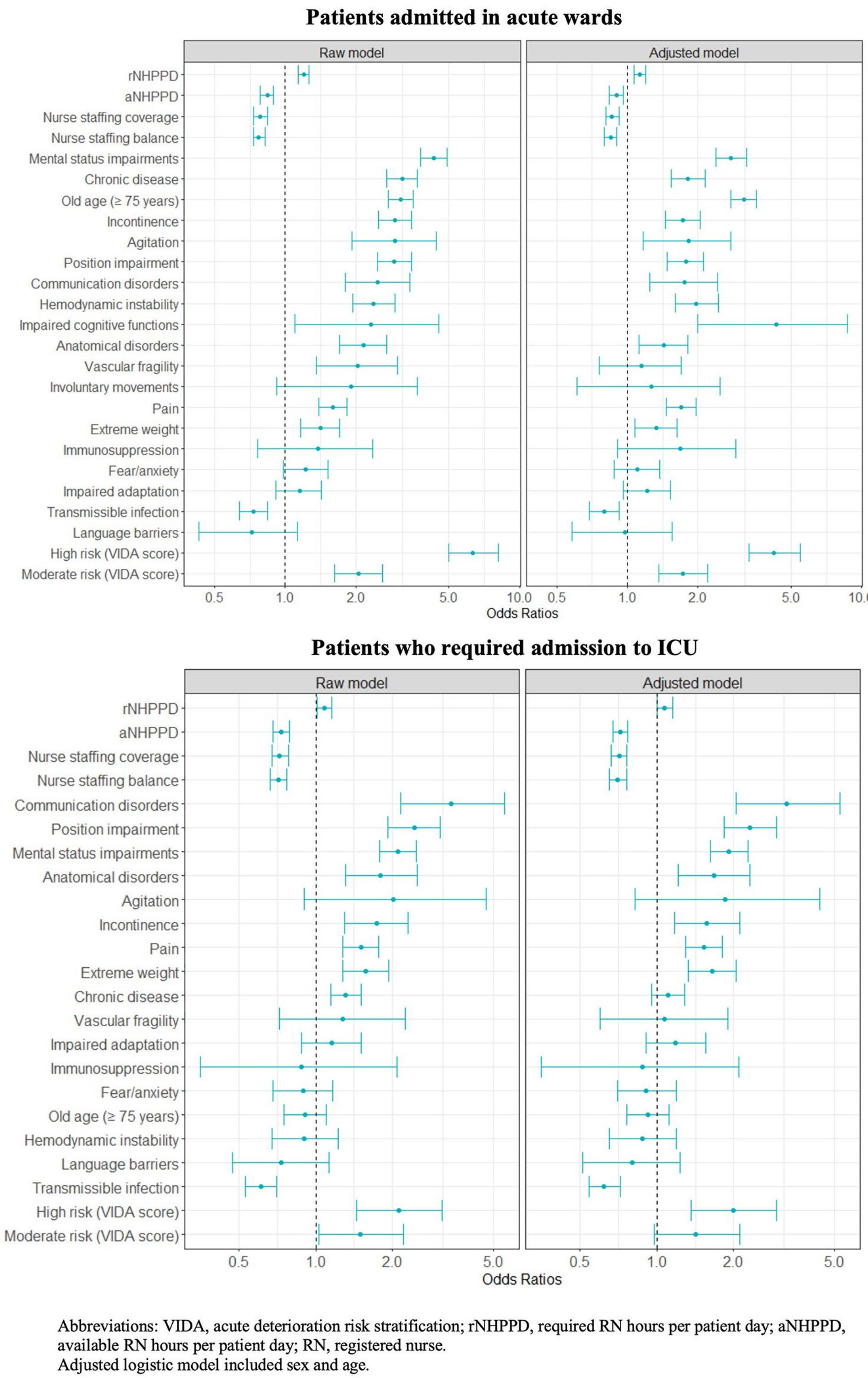

Fig. 2 Forest plot of the raw and adjusted association of every risk factor with adverse events

are probably related to the high frequency of chronic diseases in the studied sample, the organizational adaption of hospitals to this pandemic context, and the required isolation precautions that have been associated with poor outcomes in a prior study [43].

Finally, we detected an association between nurse staffing coverage and AEs, with higher nursing coverage protecting against poor outcome in patients admitted to acute wards and those who required admission to the ICU. Several studies have demonstrated the

Table 5 Multivariate association of risk factors associated with adverse events in patients admitted with COVID-19

Characteristics	ADJUSTED MODEL					
	Patients admitted to acute wards (*n* = 8,495)			Patients who required admission to ICU (*n* = 3,473)		
	OR	95% CI	*p*-value	OR	95% CI	*p*-value
Staffing measures						
Nurse staffing coverage	0.92	0.86–0.99	**0.031**	0.77	0.71–0.83	**< 0.001**
Care complexity individual factors (CCIFs)						
Haemodynamic instability	1.71	1.38–2.13	**< 0.001**	0.92	0.68–1.26	0.602
Chronic disease	1.40	1.16–1.69	**< 0.001**	1.24	1.04–1.48	**0.016**
Uncontrolled pain	1.53	1.31–1.78	**< 0.001**	1.50	1.27–1.79	**< 0.001**
Extreme weight	1.10	0.88–1.36	0.398	1.36	1.08–1.72	**0.009**
Position impairment	1.20	0.98–1.47	0.073	1.68	1.29–2.20	**< 0.001**
Urinary or faecal incontinence	1.23	1.01–1.49	**0.035**	1.18	0.85–1.63	0.327
Communication disorders	1.11	0.78–1.57	0.546	2.45	1.45–4.28	**< 0.001**
Vascular fragility	0.73	0.47–1.11	0.151	0.78	0.42–1.46	0.435
Old age	1.27	1.16–1.39	**< 0.001**	1.19	1.10–1.30	**< 0.001**
Fear/anxiety	0.88	0.68–1.11	0.289	0.99	0.74–1.31	0.937
Mental status impairments	2.35	1.99–2.77	**< 0.001**	1.94	1.61–2.34	**< 0.001**
Agitation	1.30	0.82–2.04	0.254	0.72	0.29–1.82	0.469

Abbreviations: ICU, intensive care unit; OR, odds ratio; CI, confidence interval. Adjusted logistic model included age, sex, high-tech hospital and underlying disease

association between acuity and other patient and organizational measures such as nurse staffing coverage or missed care [21, 44]. Nevertheless, this is the first study to analyse the impact of nurse staffing coverage and health outcomes in COVID-19 patients. Moreover, we detected a mean nurse staffing coverage of around 45% among patients who required ICU admission, which was slightly lower for those admitted to wards (40%). It should be noted that previous studies considered units to be understaffed when they were below the average of the usual staffing on wards or at a cut-off point below 80% of the median nurse staffing coverage in their units [45]. This data is consistent with previous inquires that found that unfavourable patient and nurse outcomes were strongly associated with poor nurse staffing coverage [6, 23]. Such chronic understaffing was widespread during the pandemic period for a variety of reasons. As previously stated, *the COVID-19 pandemic entailed novel ways of staffing, relocating nursing staff to other units, forced them to work in new roles with new tasks and new colleagues. Increased numbers of patients were expected, and there was insufficient knowledge and competence on how to care for patients with COVID-19. These circumstances could potentially impact on quality of care and patient safety* [46]. Previous evidence demonstrated that CCIFs and nurse staffing issues impact health outcomes and that, along with the poor work environment, limited management of nursing resources, and low staff competence, could compromise patient safety in terms of missed nursing care [8, 21, 47–49] and early detection of patient acute deterioration [10, 50].

In any case, 41% nurse staffing coverage is a concerning result reflecting RN understaffing in the hospital setting. Notably, a recent study examining the relationship between nurse staffing coverage and health outcomes reported significant differences across all patient AEs, in-hospital mortality and readmission when comparing those were safely nursing covered (> 90% coverage) versus under-covered (< 90% coverage) [11]. Consequently, nurse executives are challenged to improve practice environments for nurses and patients, specifically to target safe nurse staffing coverage. Therefore, it is essential that leaders within the nursing profession collaborate with policymakers, the media, and other stakeholders to shed light on this issue and implement effective strategies that address understaffing issues and improve patient outcomes [51].

Strengths and limitations

The strengths of this research include the study design and setting (multicentre cross-sectional study), its large sample size. It is the first study on the association between nurse staffing coverage and CCIFs and AEs in patients admitted with COVID-19. Importantly, we analysed two groups of patients according to whether they required admission to a ward or to critical care, given their differences in terms of nursing coverage. All data were comprehensively collected from the clinical data warehouse and all patients included had a completed nurse's electronic health record. Notwithstanding these strengths, there are some limitations that should be acknowledged. This study excluded patients directly admitted to and discharged from the

ICU because data about nursing coverage and CCIFs were not included in their electronic health records. Some patients were included in the study just when they were admitted in a general ward after being discharge from ICU. In these cases, we observed a proportion of them with no further need of isolations precautions. This may explain why the percentage of patients with CCIF transmissible infections did not achieve the 100% in our findings. Furthermore, we relied on compliance in completing the electronic health records and administrative data; however, since electronic health records are completed voluntarily, some caution is required regarding interpretation. Moreover, the high volume of patients included prevented from a detailed review of their healthcare history. Finally, a cross-sectional design of our study limiting the ability to determine causal inferences; therefore, futures prospective studies are warranted to confirm these findings.

Conclusion

A substantial number of patients admitted to acute wards with COVID-19 presented an AE during hospitalization. Multivariate analysis showed that risk factors associated with AEs in patients admitted to wards were old age, haemodynamic instability, chronic disease, uncontrolled pain, urinary or faecal incontinence and mental status impairments. Extreme weight, position impairment and communication disorders were associated with AEs in admitted patients who required admission to the ICU. Higher levels of nurse staffing coverage protected against AEs.

Therefore, these findings highlight the importance of systematically assessing patient acuity and care complexity in order to establish safety nurse staffing coverage that meets patient needs. Practically, hospitals should adopt validated patient acuity tools and early warning systems for timely detection of at-risk patients promptly; and develop targeted interventions aimed at preventing avoidable complications in COVID-19 patients. Consequently, future research and policy efforts should focus on ensuring safe nurse staffing coverage, as well as evaluating the impact of missed care, work environment, and nurses' educational level on AEs.

Abbreviations

ACC	Avoidable critical complication
AE	Adverse event
aNHPPD	Available RN hours per patient day
CCIF	Care complexity individual factors
CI	Confidence interval
HAI	Hospital-acquired infection
ICU	Intensive care unit
IQR	Interquartile range
RN	Registered nurse
rNHPPD	Required RN hours per patient day
OR	Odds ratio
SD	Standard deviation
VIDA	Acute deterioration risk stratification

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12912-025-03142-5.

Supplementary Material 1

Supplementary Material 2

Acknowledgements

We thank the CERCA Programme/Generalitat de Catalunya for institutional support.

Author contributions

Author contributions: All authors had full access to all study data and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: JA, MGS, MEJU. Team coordination: JA, MEJU. Acquisition of data: JA, MTP, MMLJ, PVV, EZP, CBM. Analysis and interpretation data: JA, MGS, EJM, SAF. Drafting of the manuscript: JA, MGS, MEJU. Critical revision of the manuscript for important intellectual content: EJM, MTP, MMLJ, PVV, EZP, CBM. Statistical analysis: JA and MGS. Obtained funding: JA. Administrative, technical and material support: PVV, EZP, CBM, SAF. Study supervision: MEJU.

Funding

This work was supported by the "Colegio Oficial de Enfermeras y Enfermeros de Barcelona" (grant PR494/2021); Spain's Ministerio de Ciencia e Innovación, Instituto de Salud Carlos III, co-financed by the European Regional Development Fund "FEDER" (grant PI21/01267); and the Departament de Recerca i Universitats de la Generalitat de Catalunya and AGAUR (grant 2021 SGR 00929).

Data availability

All data relevant to the study are included in the article or uploaded as supplemental information.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki. It was evaluated and approved by the Clinical Research Ethics Committee of the Bellvitge University Hospital (reference PR293/20), which also waived the requirement for informed consent due to retrospective nature of the study. Ethical and data protection protocols related to anonymity and data confidentiality (access to records, data encryption and archiving of information) were complied with throughout the study.

Patient consent for publication

Not required.

Competing interests

The authors declare no competing interests.

Author details

[1]Nursing Knowledge Management and Information Systems Department, Hospital Universitari de Bellvitge – IDIBELL, Feixa Llarga s/n, L'Hospitalet de Llobregat (Barcelona) 08907, Spain
[2]Faculty of Nursing, University of Barcelona, L'Hospitalet de Llobregat, Spain
[3]Infectious Disease Department, Bellvitge University Hospital, L'Hospitalet de Llobregat, Spain
[4]Nursing Management Team, Bellvitge University Hospital, L'Hospitalet de Llobregat, Spain
[5]IDIBELL, Bellvitge Institute of Biomedical Research, Barcelona, Spain
[6]Research Group on Innovation, Health Economics, and Digital Transformation (INEDIT), Germans Trias i Pujol Research Institute (IGTP), Badalona, Spain

[7]Nurse Research Coordinator, VHIR, Vall d'Hebron Institute of Biomedical Research, Barcelona, Spain
[8]Nursing Management Team, Joan XXIII University Hospital, Tarragona, Spain
[9]Catalan Institute of Health, Barcelona, Spain

Received: 7 March 2024 / Accepted: 29 April 2025
Published online: 13 May 2025

References

1. Dall'Ora C, Saville C, Rubbo B, Turner L, Jones J, Griffiths P. Nurse staffing levels and patient outcomes: A systematic review of longitudinal studies. Int J Nurs Stud. 2022;134:104311.
2. Cho E, Chin DL, Kim S, Hong O. The relationships of nurse staffing level and work environment with patient adverse events. J Nurs Scholarsh. 2016;48:74–82.
3. Cho E, Sloane DM, Kim E-Y, Kim S, Choi M, Yoo IY, et al. Effects of nurse staffing, work environments, and education on patient mortality: an observational study. Int J Nurs Stud. 2015;52:535–42.
4. Pérez-Raya F, Cobos-Serrano JL, Ayuso-Murillo D, Fernández-Fernández P, Rodríguez-Gómez JA. Almeida Souza A. COVID-19 impact on nurses in Spain: a considered opinion survey. Int Nurs Rev. 2021;68:248–55.
5. Andel SA, Tedone AM, Shen W, Arvan ML. Safety implications of different forms of understaffing among nurses during the COVID-19 pandemic. J Adv Nurs. 2022;78:121–30.
6. Lasater KB, Aiken LH, Sloane DM, French R, Martin B, Reneau K, et al. Chronic hospital nurse understaffing Meets COVID-19: an observational study. BMJ Qual Saf. 2021;30:639–47.
7. Padula WV, Davidson P. Countries with high registered nurse (RN) concentrations observe reduced mortality rates of coronavirus disease 2019 (COVID-19). SSRN Electron J. 2020;3566190.
8. Harrison JM, Aiken LH, Sloane DM, Brooks Carthon JM, Merchant RM, Berg RA, et al. Hospitals with more nurses who have baccalaureate degrees, better outcomes for patients after cardiac arrest. Health Aff. 2019;38:1087–94.
9. Aiken LH, Sloane DM, Van den Bruyneel L, Sermeus W. Nurses' reports of working conditions and hospital quality of care in 12 countries in Europe. Int J Nurs Stud. 2013;50:143–53.
10. Adamuz J, González-Samartino M, Jiménez-Martínez E, Tapia-Pérez M, López-Jiménez MM, Rodríguez-Fernández H, et al. Risk of acute deterioration and care complexity individual factors associated with health outcomes in hospitalised patients with COVID-19: A multicentre cohort study. BMJ Open. 2021;11:e041726.
11. Juvé-Udina M, Adamuz J, González-Samartino M, Tapia-Pérez M, Jiménez-Martínez E, Berbis-Morello C, et al. Association between nurse staffing coverage and patient outcomes in a context of prepandemic structural understaffing: A patient-Unit-Level analysis. Wiley J Nurs Manage. 2025;2025:14.
12. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395:497–506.
13. Jafari-Oori M, Ghasemifard F, Ebadi A, Karimi L, Rahimi-Bashar F, Jamialahmadi T, et al. Acute respiratory distress syndrome and COVID-19: A scoping review and Meta-analysis. Adv Exp Med Biol. 2021;1321:211–28.
14. Zhang J, Dong X, Liu G, Gao Y. Risk and protective factors for COVID-19 morbidity, severity, and mortality. Clin Rev Allergy Immunol. 2022;64:90–107.
15. Zheng Z, Peng F, Xu B, Zhao J, Liu H, Peng J, et al. Risk factors of critical & mortal COVID-19 cases: A systematic literature review and meta-analysis. Journal of Infection. 2020;81:e16–25.
16. Xu PP, Tian RH, Luo S, Zu ZY, Fan B, Wang XM, et al. Risk factors for adverse clinical outcomes with COVID-19 in China: a multicenter, retrospective, observational study. Theranostics. 2020;10:6372–83.
17. Wu C, Chen X, Cai Y, Xia J, Zhou X, Xu S, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med. 2020;180:934–43.
18. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395:1054–62.
19. Welton JM. Measuring patient acuity. Implications for nurse staffing and assignment. JONA: J Nurs Adm. 2017;47:471–471.
20. Juvé-Udina ME, Adamuz J, López-Jimenez MM, Tapia-Pérez M, Fabrellas N, Matud-Calvo C, et al. Predicting patient acuity according to their main problem. J Nurs Manag. 2019;27:1845–58.
21. Juvé-Udina ME, González-Samartino M, López-Jiménez MM, Planas-Canals M, Rodríguez-Fernández H, Batuecas Duelt IJ, et al. Acuity, nurse staffing and workforce, missed care and patient outcomes: A cluster-unit-level descriptive comparison. J Nurs Manag. 2020;28:2216–29.
22. Juvé-Udina ME, Adamuz J. Nursing knowledge tools and strategies to improve patient outcomes and the work environment. In: Gantz NR, Hafsteinsdóttir TB, editors. Mentoring in nursing through narrative stories across the world. Springer International Publishing; 2023. pp. 211–22.
23. Jiménez-Martínez E, Adamuz J, González-Samartino M, Muñoz-Carmona MA, Hornero A, Martos-Martínez MP, et al. Peripheral intravenous catheter failure, nurse staffing levels and care complexity individual factors: A retrospective multicentre cohort study. PLoS ONE. 2024;19:e0303152.
24. Adamuz J, Juve-Udina ME, Gonzalez-Samartino M, Jimenez-Martinez E, Tapia-Perez M, Lopez-Jimenez MM, et al. Care complexity individual factors associated with adverse events and in-hospital mortality. PLoS ONE. 2020;15:e0236370.
25. Juvé-Udina ME, Matud C, Farrero S, Jiménez H, Rodríguez E, Martínez M, et al. Intensity of nursing care: workloads or individual complexity? Metas De Enfermería. 2010;13:6–14.
26. Adamuz J, González-Samartino M, Jiménez-Martínez E, Tapia-Pérez M, López-Jiménez MM, Ruiz-Martínez MJ, et al. Care complexity individual factors associated with hospital readmission: A retrospective cohort study. J Nurs Scholarsh. 2018;50:411–21.
27. Juvé-Udina ME. What patients' problems do nurses e-chart? Longitudinal study to evaluate the usability of an interface terminology. Int J Nurs Stud. 2013;50:1698–710.
28. Castiello T, Georgiopoulos G, Finocchiaro G, Claudia M, Gianatti A, Delialis D, et al. COVID-19 and myocarditis: a systematic review and overview of current challenges. Heart Fail Rev. 2022;27:251–61.
29. Hilton J, Boyer N, Nadim MK, Forni LG, Kellum JA. COVID-19 and acute kidney injury. Crit Care Clin. 2022;38:473–89.
30. Baker MA, Sands KE, Huang SS, Kleinman K, Septimus EJ, Varma N, et al. The impact of coronavirus disease 2019 (COVID-19) on Healthcare-Associated infections. Clin Infect Dis. 2022;74:1748–54.
31. Bardi T, Pintado V, Gomez-Rojo M, Escudero-Sanchez R, Azzam Lopez A, Diez-Remesal Y, et al. Nosocomial infections associated to COVID-19 in the intensive care unit: clinical characteristics and outcome. Eur J Clin Microbiol Infect Dis. 2021;40:495–502.
32. Acharya P, Ranka S, Sethi P, Bharati R, Hu J, Noheria A, et al. Incidence, predictors, and outcomes of In-Hospital cardiac arrest in COVID-19 patients admitted to intensive and Non-Intensive care units: insights from the AHA COVID-19 CVD registry. J Am Heart Assoc. 2021;10:e021204.
33. Shahid Z, Kalayanamitra R, McClafferty B, Kepko D, Ramgobin D, Patel R, et al. COVID-19 and older adults: what we know. J Am Geriatr Soc. 2020;68:926–9.
34. Szklarzewska S, Vande Walle J, De Breucker S, Schoevaerdts D. A comparison of clinical characteristics between old and oldest-old patients hospitalised for SARS-COV2. Acta Clin Belg. 2023;78:192–9.
35. Blomaard LC, van der Linden CMJ, van der Bol JM, Jansen SWM, et al. Frailty is associated with in-hospital mortality in older hospitalised COVID-19 patients in the Netherlands: the COVID-OLD study. Age Ageing. 2021;50:631–40.
36. Garrigues E, Janvier P, Kherabi Y, Le Bot A, Hamon A, Gouze H, et al. Post-discharge persistent symptoms and health-related quality of life after hospitalization for COVID-19. J Infect. 2020;81:e4–6.
37. Ammirati E, Lupi L, Palazzini M, Hendren NS, Grodin JL, Cannistraci CV, et al. Prevalence, characteristics, and outcomes of COVID-19–Associated acute myocarditis. Circulation. 2022;145:1123–39.
38. Kostakis I, Smith GB, Prytherch D, Meredith P, Price C, Chauhan A, et al. The performance of the National early warning score and National early warning score 2 in hospitalised patients infected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Resuscitation. 2021;159:150–7.
39. Dessie ZG, Zewotir T. Mortality-related risk factors of COVID-19: a systematic review and meta-analysis of 42 studies and 423,117 patients. BMC Infect Dis. 2021;21:855.
40. Kim L, Garg S, O'Halloran A, Whitaker M, Pham H, Anderson EJ, et al. Risk factors for intensive care unit admission and In-hospital mortality among hospitalized adults identified through the US coronavirus disease 2019 (COVID-19)-Associated hospitalization surveillance network (COVID-NET). Clin Infect Dis. 2021;72:E206–14.

41. Young DR, Sallis JF, Baecker A, Cohen DA, Nau CL, Smith GN, et al. Associations of physical inactivity and COVID-19 outcomes among subgroups. Am J Prev Med. 2023;64:492–502.
42. Regan J, Walshe M, Lavan S, Horan E, Murphy PG, Healy A, et al. Dysphagia, dysphonia, and dysarthria outcomes among adults hospitalized with COVID-19 across Ireland. Laryngoscope. 2022;132:1251–9.
43. Purssell E, Gould Di, Chudleigh J. Impact of isolation on hospitalised patients who are infectious: systematic review with meta-analysis. BMJ Open. 2020;10:e030371.
44. Lasater KB, McHugh M, Rosenbaum PR, Aiken LH, Smith H, Reiter JG, et al. Valuing hospital investments in nursing: multistate matched-cohort study of surgical patients. BMJ Qual Saf. 2020;30:46–55.
45. Shang J, Needleman J, Liu J, Larson E, Stone PW. Nurse staffing and Healthcare-Associated infection, Unit-Level analysis. J Nurs Adm. 2019;49:260–5.
46. Vogelsang A, Göransson KE, Falk A, Nymark C. Missed nursing care during the COVID-19 pandemic: A comparative observational study. J Nurs Manag. 2021;29:2343–52.
47. Park SH, Hanchett M, Ma C. Practice environment characteristics associated with missed nursing care. J Nurs Scholarsh. 2018;50:722–30.
48. Labrague LJ, Santos JAA, Fronda DC. Factors associated with missed nursing care and nurse-assessed quality of care during the COVID-19 pandemic. J Nurs Manag. 2022;30:62–70.
49. Squires A, Clark-Cutaia M, Henderson MD, Arneson G, Resnik P. Should I stay or should I go? Nurses' perspectives about working during the Covid-19 pandemic's first wave in the united States: A summative content analysis combined with topic modeling. Int J Nurs Stud. 2022;131:104256.
50. Juvé-Udina ME, Fabrellas-Padrés N, Adamuz-Tomás J, Cadenas-González S, Gonzalez-Samartino M, de la Ariza L. C, Surveillance nursing diagnoses, ongoing assessment and outcomes on in-patients who suffered a cardiorespiratory arrest. Revista Da Escola De Enfermagem. 2017;51: e03286
51. Jadidi A, Sadeghian E, Khodaveisi M, Maghsoudi Z, Razavi MR. The Iranians' attitude toward the social status of the nursing profession. Health Educ Health Promotion. 2022;10:123–7.

Publisher's note