Table 5. Results of the non-comparative observational studies

First author, year	Study design, Population Setting Country	Definition variable 'nurse-patient ratio' / nurse-workload ratio'	Analysis, confounders	Results
Stone, 2007	Observational study, with patient outcome data collected using the National Nosocomial Infection Surveillance system protocols and Medicare files. Elderly Medicare ICU patients (>65 years); 15,846 patients in 51 adult intensive care units in 31 hospitals; United States.	Staffing: registered nurse hours per patient day, in quartiles (higher quartiles = more RN hours per patient day)	Multivariate logistic regressions were constructed for each outcome. Robust variance estimators (Huber–White) were calculated and analyses were clustered at the hospital level to allow for an arbitrary variance– covariance matrix, adjusted odds ratios (OR) and 95% confidence intervals (CI) were examined. All models are adjusted for a comprehensive set of (1) patient characteristics, including severity of illness, comorbidities, demographics, and socioeconomic status, and (2) setting characteristics, including hospital size and teaching status and ICU type and case-mix.	<u>30-day mortality (n=15,846)</u> The average 30-day mortality rate was 22% (3,185 of 15,846) Adjusted OR (95% CI) Second quartile: 0.89 (0.77–1.02) Third quartile: 0.81 (0.69–0.95) Fourth quartile: 0.89 (0.76–1.05) <u>VAP (n=5,462)</u> Overall rate: VAP 1.5% (81 of 5,462) Adjusted OR (95% CI) Second quartile: 0.71 (0.43–1.19) Third quartile: 0.68 (0.39–1.21) Fourth quartile: 0.21 (0.08–0.53)
Cho, 2008	Observational study, retrospective; Using survey and administrative databases, this study included 27,372 ICU patients discharged from 42 tertiary and 194 secondary hospitals; Korea.	Staffing of RNs was quantified as the ratio of average daily census (ADC) to the total number of full-time equivalent (FTE) RNs in ICUs, termed the ADC/RN ratio, by dividing ADC by the number of fte RNs. The RN staffing included not only staff nurses but also head nurses who would have no direct responsibility for patient care.	Data were treated as having a two-tiered structure to use multilevel analysis. The first tier was the hospital level, in which the variables of hospital and ICU characteristics were aggregated. The second tier was the patient level where patient characteristics were measured. Using the patient as the unit of analysis, all variables of the two levels were included simultaneously into the regression model. This multilevel modeling allowed simultaneous examination of the effects of nurse staffing, ICU, hospital, and patient	<u>Mortality</u> ADC/RN ratio, Adjusted OR (95%CI) Tertiary hospitals: 0.54 (0.22-1.33) Secondary hospitals: 1.43 (1.16-1.77) This OR of 1.43 indicates that every additional patient per RN (i.e., an increase of 0.233 in the ADC/RN ratio) was associated with a 9% increase in the odds of death (OR = 1.09, 95%CI = 1.04-1.14). Two and three additional patients would be accompanied by 18% and 29% increases in mortality, respectively.

			characteristics on mortality. Tertiary and secondary hospitals were analyzed separately under the assumption that they treated groups of patients with a different level of illness severity, clinical features, and ICU utilization patterns, including admission and discharge policies. Patient characteristics: mortality, age, gender, source of payment, primary diagnosis, and comorbid disease were used for risk adjustment.	
Graf, 2010	Observational study; data were collected prospectively on a cross-sectional (one-day) basis in a representative random sample of German hospitals. The final data set comprised information on 454 ICUs and 310 hospitals.	Nurse staffing (number of patients a nurse was responsible for)	For the analysis of a potential association between structural characteristics or associated processes of the ICU with the outcome (in-hospital mortality) of patients with severe sepsis or septic shock, multiple hypotheses testing was performed.	"For all patients with severe sepsis and septic shock we tested the hypothesis whether structural characteristics or associated processes of the ICU are related to outcomes, i.e., in-hospital mortality. We neither found any significant association with nurse staffing, physician presence, size of hospital or ICU, nor with diagnostic measures or applied therapeutic interventions, after correction for multiple hypothesis testing."
Checkley, 2014	Observational study; 69 ICU's participating in the United States Critical Illness and Injury Trials Group Critical Illness Outcomes Study (USCIITG-CIOS) were surveyed; United States	bed-to-nurse ratio	The multivariable linear regression model included the following variables: average APACHE II score, ICU type, case volume, bed capacity, 24-hour intensivist coverage, bed-to-nurse ratio, trainee-to-bed ratio, ICU organization (open vs. closed), computerized order entry, daily plan of care review, multidisciplinary rounding, and use of protocols guiding management of electrolytes, mobility, codes, neuroprotection, delirium, and transfusions.	<u>Annual ICU Mortality</u> Bed-to-nurse ratio (per 1:1 unit increase) % difference in annual ICU mortality (95% CI): • Single variable analysis: 2.4 (1.8 to 3.1) • Adjusted for APACHE II and ICU type: 2.1 (−0.3 to 4.6) • Multivariable analysis: 3.7 (0.5 to 6.8) The adjusted annual ICU mortality was lower among ICUs that had a lower bed-to-nurse ratio (1.8% lower when the ratio decreased from 2:1 to 1.5:1; 95% CI 0.25%–3.4%).
Talsma, 2014	Observational study; A 3-year (2003-2005) multisite study was designed to include all acute care cases that met the inclusion criteria of the AHRQ Patient	Nurse staffing data included total nursing direct HPPD,	Multilevel analyses were used to take into account the hierarchical structure of the database: patients clustered on nursing	<u>Patient mortality because of complications (FTR, failure to rescue)</u> OR (95% Wald CI) HPPD: 1.015 (0.935, 1.102)

	Safety Indicator (PSI) FTR; Southeast Michigan, United States	RN HPPD, and RN staffing mix: the proportion of registered nurses (RNs) on the unit. HPPD = Nursing Hours Per Patient Day	units, which are clustered within hospitals. Because the outcome variable (FTR rate) was defined as dichotomous, a multilevel logistic model was used. We were interested in examining the effect of nurse staffing measures (unit characteristics) on FTR rate, controlling for patient demographic and clinical conditions (patient characteristics), and other unit characteristics.	RN_HPPD: 1.031 (0.942, 1.130) RN_MIX: 1.037 (0.976, 1.101) The findings for the ICU discharges showed no significant associations between increased HPPD, RN_HPPD, and RN-mix and reduced FTR.
West, 2014	Observational study; Data for the six months before and after March 1998, which had been collected prospectively, were merged onto organizational data on 65 ICUs surveyed by the Audit Commission. The matched dataset contained information only on ICUs in England.	Number of nurses per bed: This variable counts the number of full-time equivalent nurses on the permanent staff of the ICU on one specific date (the date of the Audit Commission survey). The question on the survey asked for separate information on registered nurses and health care assistants. The variable used in these analyses is a count of the registered nurses at different grades who were in post on the census date. It is important to note that this is not the number of nursing staff available for duty when any particular patient is admitted. Two separate variables: the number of direct care nurses and the number of supernumerary nurses.	Multilevel logistic regression was used to perform all the analyses. Risk adjustment based on ICNARC score (physiology model, including blood pressure, respiratory rate, oxygenation, and acid base disturbance, along with a range of other factors known to be associated with mortality, including age, past medical history, and source of admission to an ICU).	ICU mortality Number of direct care nurses per bed, OR from multilevel logistic regression models [95%CI] Model 1: 0.90 [0.84,0.97] Model 2*: 0.90 [0.83,0.97] Model 3*: 0.90 [0.83,0.97] Mortality in acute hospital Model 1: 0.92 [0.87,0.98] Model 2*: 0.92 [0.86,0.98] Model 3*: 0.92 [0.86,0.98] *Further, as we believe that the effect of staffing might depend on the severity of a patient's illness; in the second column we add an interaction between the number of nurses and predicted log odds of mortality, while in column 3 we add an interaction between the number of consultants and predicted log odds of mortality. The most significant findings are that, controlling for patient characteristics and the workload of the unit, higher numbers of nurses per bed on the unit's establishment and higher numbers of consultants per bed were both

				associated with higher survival rates.
Neuraz, 2015	Multicenter longitudinal study using routinely collected hospital data, January to December 2013; 8 ICU's from 4 university hospitals in Lyon, France; 5,718 inpatient stays.	Patient-to-nurse (P/N) ratio by shift in five categories: • less than or equal to 1:1 • greater than 1:1 to less than or equal to 1.5:1 • greater than 1.5:1 to less than or equal to 2:1 • greater than 2:1 to less than or equal to 2.5:1 • greater than 2.5:1 (2:1 meaning two patients for one nurse).	To control for potential confounding variables, patients' characteristics were a priori selected as clinically important covariates. The proportion of surgical cases versus medical cases was used to adjust on the type of patient case-mix admitted to ICU. The final multivariate model included the following variables: P/N, P/P (patients/physician) and residents-to-physicians ratios, patient turnover, number of LSP, proportion of men, proportion of surgical cases, SAPSII, and number of comorbidities.	Mortality: The primary outcome was mortality at time of ICU discharge by shift, excluding patients for whom a DFLST (decision to not forego life sustaining therapy) was made. The fully adjusted model, taking into account both staffing and workload levels, showed an increased risk of mortality, with the highest values for P/P and P/N. The ICU risk of death increased by a factor of 3.5 (1.3–9.1) when the number of patients was above 2.5 per nurse.
Faisy, 2016	Prospective, observational, dynamic cohort study; January 2006 to December 2013; a 20-bed adult medical intensive care unit of a tertiary teaching hospital in France	Bed-to-nurse ratio	Negative binomial regression for over-dispersed count outcome variables was then used to model the rate of severe adverse events because of the spread of severe adverse events over time. In the univariate and multivariate analyses, covariates were adjusted by the bed-to-nurse ratio, which reflects nursing workload and intensive care unit activity (Massey et al., 2009), thereby limiting confounding factors. Bed-to-nurse ratio was preferred to patient-to-nurse ratio because of the monthly changes in nurse staff and bed availability. In addition, an offset has been included in the model (volume of intensive care unit activity on the basis of the number of billable journeys) because the higher the activity the higher the risk of adverse events.	Severe adverse events: Incidence rate ratio (95% CI) Univariate: 1.28 (0.99–1.66) Multivariate: 1.36* (1.05–1.75) *Indicates the estimated incidence rate ratio for a one-unit increase in the bed-to-nurse ratio. Thus, if the bed-to-nurse ratio was to increase by one point, the monthly rate for severe adverse events would be expected to increase by a factor of 1.36, i.e., 36%
Lee, 2017	Retrospective analysis of prospectively collected data	Workload/nurse ratio:	Pearson's r was used to test for co-linearity between TISS and workload-to-staffing ratio.	The lower 90% confidence interval crosses zero when the workload/staffing ratio is 40. This indicates that there is more than 95% probability that survival

	Adult patients admitted to two multi-disciplinary Intensive Care Units; Hong Kong	Nursing workload (TISS-score) / average number of bedside nurses		to hospital discharge is more likely to occur when the maximum workload to-nurse ratio is 52. Outcome: Survival Comparison: Workload/staffing < 40 vs. 40 or higher APACHE III score of 60 OR 2.28, 95% CI 1.07–4.80 APACHE III score of 70-130 No sign difference between < 40 vs. 40 or higher APACHE III >130 OR 0.24, 95% CI 0.09–1.01
Kim, 2018	Observational; Retrospective database study Patients admitted with cardiovascular (CV) disease; Study data were obtained from National Health Insurance Service-Senior (NHIS-Senior) claim database from 2002 to 2013 which was released by the Korean National Health Insurance Service (KNHIS).	Nurse staffing*: nurse staffing grades were based on the nurse-to-bed ratio. The highest nurse staffing grade was grade 1 (beds/ nurse ratio <0.5), with the lowest nurse staffing grade being grade 9 (beds/nurse ratio ≥2.0). Level of nurse staffing was categorized into 4 groups in each year: grade 1 to 2, grade 3 to 4, grade 5 to 6, and grade 7 to 9.	Cox proportional hazards models were used to investigate the association between nurse staffing and mortality; adjusted for all confounders.	*Tertiary hospital; per level of nurse staffing** 30-day mortality after discharge Grade 1–2: HR 1.000 (ref) Grade 3–4: HR 1.038 (SE 0.120); p=.755 Grade 5–6: HR 1.382 (SE 0.323); p=.316 Grade 7–9: HR 0.967 (SE 0.106); p=.752 In-hospital 30-day mortality Grade 1–2: HR 1.000 (ref) Grade 3–4: HR 1.127 (SE 0.124); p=.333 Grade 5–6: HR 1.171 (SE 0.358); p=.658 Grade 7–9: HR 0.998 (SE 0.112); p=.982 *General hospital; per level of nurse staffing* 30-day mortality after discharge Grade 1–2: HR 1.000 (ref) Grade 3–4: HR 1.367 (SE 0.159); p=0.049 Grade 5–6: HR 1.353 (SE 0.180); p=0.093 Grade 7–9: HR 1.499 (SE 0.156); p= 0.010 In-hospital 30-day mortality Grade 1–2: HR 1.000 (ref) Grade 3–4: HR 1.277 (SE 0.160); p=.126 Grade 5–6 : HR 1.233 (SE 0.183); p=.250 Grade 7–9 : HR 1.377 (SE 0.157); p=.042

Verburg, 2018	Observational study, retrospective; data from the Dutch National Intensive Care Evaluation (NICE) registry. 78,822 admissions, 38 ICU's; the Netherlands	Full-time equivalent ICU nurses	Mixed effects regression models; examined the association between ICU characteristics available in the NICE registry and ICU LoS, after correcting for patient characteristics.	<u>ICU length of stay</u> *Models including a single ICU characteristic* Full-time equivalent ICU nurses, coefficient (95%CI): -0.017 (−0.021 to −0.013) *Final model including multiple ICU characteristics* Full-time equivalent ICU nurses, coefficient (95%CI): −0.030 (−0.034 to −0.025) The coefficients represent the change in log transformed intensive care unit length of stay associated with the characteristic. We found that the ICU LoS increased as the number of ICU nurses decreased.
Jansson, 2019	prospective, observational cohort study consecutive adult patients who were admitted to the mixed medical-surgical ICU and received invasive ventilation over 48 hours were recruited and monitored daily for the development of VAP until ICU discharge or death 900-bed tertiary-level teaching hospital; adult, closed, mixed medical-surgical ICU with 22 beds (four 1-bed rooms, three 2-bed rooms, four 3-bed rooms), Finland	Daily N/P ratio: dividing the total number of nurses by the total number of patients for each calendar day. ICNSS = Intensive Care Nursing Scoring System → nurse workload	Receiver operating characteristic (ROC) curve and the area under the curve (AUC) were used to determine the associations between nurse staffing and workload with VAP and mortality	N/P ratio *Lowest* Patients without VAP: 1.0 (1.0-1.1) Patients with VAP: 1.0 (0.9-1.0) P= 0.006* AUC: 0.3 (0.2-0.4) *Median* Patients without VAP: 1.2 (1.2-1.3) Patients with VAP: 1.2 (1.2-1.3) P=0.98 AUC: 0.5 (0.4-0.6) ICNSS score *Highest* Survivor: 36.0 (33.0-39.0) Non-survivor: 38.0 (34.0-41.8) P=0.09 AUC: 0.6 (0.5-0.8) *Median* Survivor: 30.0 (28.1-32.0) Non-survivor: 31.0 (30.0-34.0) P=0.03*

				AUC: 0.7 (0.5-0.8)
Kim, 2019	Observational retrospective study; using NHI claim data on patient and hospital characteristics for 2140 patients undergoing craniotomy or percutaneous angioplasty from January to December 2009; Korea	The NHI claim data quantified nurse staffing levels using the nursing grade, which is based on the nurse-to-bed ratios in general wards and the ICUs; Nurse-to-bed ratio converted to nurse-to-patient ratio using an occupancy rate of 86%. ICU nurse staffing level: - major adherence - adherence - violation	Logistic regression applied with a generalized estimation model in order to adjust clustered data was used to analyze the associations between the nurse staffing level and survival after cardiac arrest. The same analysis was performed for the hospital type. Hospitals and general hospitals were categorized into one group, with tertiary hospitals classified separately.	<u>Patient survival</u> Patients who were cared for in tertiary hospitals with major adherence ICUs nurse staffing were 2.35-fold more likely to survive than those in tertiary hospitals with adherence nurse staffing (95% CI = 1.27–4.36). The patient survival rate after cardiac arrest did not differ significantly between violation nurse staffing and adherence nurse staffing in general wards in tertiary hospitals.
Jansson, 2020	Cross-sectional study in a single tertiary-level teaching hospital during 2008–2017; 900-bed tertiary-level teaching hospital in Finland. All admissions were identified from the hospital database. Patients were eligible for inclusion if they were adults (≥18 years), were admitted to the ICU between 1 January 2008 and 31 December 2017 (N = 13,720) and had complete data sets regarding nurse staffing and nursing workload. Because our focus was on high-risk critically ill patients, patients with low-risk elective surgery (e.g. cardiac surgery or neurosurgery) were excluded to reduce case mix heterogeneity. In total, 10,230 patients met the inclusion criteria and were included for further analysis	The level of nurse staffing was recorded by collecting the total number of nurses and patients throughout each calendar day (i.e. morning, evening and night shifts). The daily N/P ratio was determined by dividing the total number of nurses by the total number of patients for each calendar day. Only the daily lowest N/P ratios for each calendar day were considered. The daily ICNSS index was determined by dividing the sum of nurses needed by the sum of available nurses during each day. Only the daily highest indexes for each calendar day were considered.	Additionally, multivariable linear regression models were used to get adjusted results between MOF (no/yes), hospital mortality (no/yes) and a subgroup of MOF patients (early- vs. late-stage MOF) for TISS scores, ICNSS scores, N/P ratios and ICNSS indexes. Age, gender, APACHE II scores, admission type (emergency/elective), surgery (no/yes) and N/P ratios were used as adjustable variables, except for the N/P ratios for the models of the N/P ratio itself and the ICNSS index. The results for the Student's t test and linear regression model are presented as the difference between means with a 95% confidence interval (95% CI) Shifts were categorized as understaffed (yes/no) if they had N/P ratios <1 and ICNSS indexes >1 and a shift's adjusted impact on MOF and hospital mortality was calculated using a multivariable logistic regression model. Age, gender, APACHE II	<u>Multiple organ failure (MOF):</u> In the subgroup analysis, the mean daily lowest N/P ratio prior to MOF was lower in patients with late-stage than those with early-stage MOF. In addition, the mean daily highest ICNSS index was higher in patients with late-stage MOF. The proportion of N/P ratio <1 and ICNSS index >1 was significantly more common in patients with MOF than in those without. In the subgroup analysis, the proportion of N/P ratio <1 and ICNSS index >1 was significantly more common in patients with late-stage than those with early-stage MOF. The proportion of understaffing did not differ between survivors and non-survivors. *N/P ratio < 1* 4,612 of 8,204 (56.3%) patients without MOF; 1,578 of 2,026 (77.9%) patients with MOF. Adjusted OR=2.59 (2.29 to 2.92). <u>In-hospital mortality</u>

			score, admission type (emergency/elective) and surgery (no/yes) were used as adjustable variables. The results of the logistic regression model are presented as an odds ratio (OR) with a 95% CI.	The AUC values for the mean daily lowest N/P ratios for in-hospital mortality were 0.51 (95% CI 0.47–0.54) in patients with early-stage MOF and 0.46 (95% CI 0.38–0.54) in patients with late-stage MOF respectively.
Ding, 2022	Observational; Retrospective database study; The data in this study were collected between January 1, 2019, and December 31, 2019.. The data source was the National Clinical Improvement System ((https://ncisdc.medidata.cn/login.jsp), collected by the China-National Critical Care Quality Control Center (China-NCCQC), which is the official national department that regulates ICU quality control in China.	patient-to-bed ratio (calculated by the total number of ICU patients divided by the number of beds in the ICU), physician-to-bed ratio (calculated by the total number of ICU physicians divided by the number of beds in the ICU), nurse-to-bed ratio (calculated by the total number of ICU nurses divided by the number of beds in the ICU), patient-to-physician ratio (calculated by the total number of ICU patients divided by the number of ICU physicians), patient-to-nurse ratio (calculated by the total number of ICU patients divided by the number of nurse).	Poisson regression analysis (generalized linear model for count data)	VAP incidence rate (β (95% CI), p-value) Nurse-to-bed ratio: -0.146 (-0.229, -0.063), 0.0006 Patient-to-nurse ratio: -0.015 (-0.019, -0.011), <0.0001 VAP mortality (β (95% CI), p-value) Nurse-to-bed ratio: 0.038 (-0.17, 0.246), 0.7186 Patient-to-nurse ratio: -0.002 (-0.014,0.009), 0.6918 Structural factors associated with lower ICU VAP incidence rate included patient-to-bed ratio (β=−0.002 (−0.004,−0.001), p=0.0126), nurse-to-bed ratio (β=−0.146 (−0.229,−0.063), p=0.0006), patient-to-nurse ratio (β=−0.015 (−0.019, −0.011), p<0.0001).
Kim, 2022	Retrospective cohort study design using the National Health Insurance Sampling (NHIS) cohort data from 2014 to 2015, Korea. A total of 13,135 ICU patients were included.	Nurse staffing level was classified as nine grades in the ICU at the time of this study. The level of nurse staffing by nurse-to-bed ratio in the ICU used data that was provided in insurance claims. If the nurse-to-bed ratio was less than 0.5, it was classified as 1st grade, 1 ~ 5th grade (5 grade: ≥1.00), or	The generalized estimating equation (GEE) model was used to evaluate the association between nurse staffing level and LOS; GEE model with a gamma distribution and log-link function because the hospital's LOS is right-skewed. In the fully adjusted model, all variables were entered simultaneously.	Length of stay: Per nurse staffing level (M±SD) Level 1 16.39 ±17.49 Level 2 16.70 ±15.50 Level 3 16.20 ±16.20 Level 4 15.71 ±15.51 Level 5 16.61 ±15.44 Level 6 17.08 ±18.37 Level 7 17.70 ±21.30 Level 8 15.91 ±14.36

		1 ~ 9th grade (9 grade, ≥2.00) for ICU, tertiary hospitals, hospitals, and general hospitals, respectively. Since the nurse staffing level entered in the claim data was based on the nurse-to-bed ratio, the nurse-to-patients ratio was calculated based on the total number of in-patients and nurses in each hospital. Next, we classified nurse staffing level into eight grades based on the current nurse-to-patient ratio.		Level 9 15.62 ±15.75 Significant differences in the LOS according to the nurse staffing grade were observed in ICUs, with a longer LOS in nurse staffing grade 6 (mean [M]: 17.08, standard deviation [SD]: 18.37) and grade 7 (M: 17.70, SD: 21.30) institutions. Depending on the hospital type, LOS was found to be longest in a hospital (M: 19.35, SD: 18.49) and shortest in a tertiary hospital (M: 16.37, SD: 16.28). Associations between nurse staffing level and length of stay, RR (95%CI): Level 1 0.919 (0.844 to 1.001) Level 2 0.906 (0.871 to 0.942) Level 3 0.913 (0.881 to 0.946) Level 4 0.947 (0.907 to 0.995) Level 5 1.012 (0.951 to 1.076) Level 6 1.115 (1.057 to 1.176) Level 7 – Level 8 1.031 (0.959 to 1.109) Level 9 1.009 (0.931 to 1.094) In general, higher nurse staffing levels were associated with shorter LOS. In the ICU, the level of nurse staffing in grades 4 and above resulted in reduced LOS compared to grade 7; however, only grades 2 to 4 were statistically significant. Nurse staffing level grades 8 and 9 were associated with a higher LOS compared to grade 7; however, this result was not statistically significant
Duclos, 2023	Retrospective multicenter observational study, Lyon, France; 8 academic ICUs over 6 years (43,479 ICU patients) between January 1, 2011 and December 31, 2016.	The patient-to-nurse ratio and the patient-to-assistant nurse ratio were defined as the number of patients per nurse and per assistant nurse by shift, respectively. According to the	Mortality assessment was systematically adjusted for patient characteristics (age, sex, admission context, SAPS II, and comorbidities), nursing team members' workload (patient turnover, number of LSPs per patient, and proportion of isolated	<u>ICU mortality:</u> There were 3,101 shifts (9%) during which at least one death without a DFLST occurred during the ICU stay, including 2,902 shifts (8%) with one death. The risk of shift with death increased in the case of

		French law that recommends five ICU patients per two nurses and four ICU patients per one assistant nurse, the patient-to-nurse and patient-to–assistant nurse ratios were categorized as suboptimal when not complying with this guideline (i.e., more than five patients for two nurses and more than four patients for one assistant nurse, respectively) and as optimal otherwise.	patients), time periods (year, quarter, and weekend), and staffing (experience length of nursing team members and patient-to-staffing ratios). To identify the determinants of ICU mortality per shift and account for the clustering effect of patients within the ICU (i.e., patients treated and outcomes within a particular ICU tended to be more similar than those in another ICU), we computed multivariate modified Poisson regression (with a robust standard error estimation) and applied a small sample correction factor to take into account the low number of clusters (19). The potential confounders described above were a priori entered in the model. We tested and included any significant interactions between variables in the model. The results were presented as adjusted relative risks (RRs) with their corresponding 95% confidence intervals (95% CIs). We plotted shifts with at least one death without DFLST according to nurse-to-nurse familiarity in an unadjusted and adjusted model. We estimated predicted probabilities with their 95% CIs from modified Poisson regression models with a robust error variance.	suboptimal patient-to-nurse ratio (RR=1.35; 95%CI 1.02 to 1.77; P = 0.035). <u>Shifts with death within 12 hours:</u> There were 731 shifts (2%) during which at least one patient death occurred within 12 hours of their ICU admission. The risk of shift with death increased in the case of suboptimal patient-to-nurse ratio (RR, 1.84; 95% CI, 1.43–2.38; P < 0.001) and suboptimal ratios for both nurses and assistant nurses (RR, 3.16; 95% CI, 1.94–5.14; P < 0.001)
Zhou, 2023	Retrospective study of single-center ICUs in China; 1,341 consecutive septic patients admitted to the emergency ICU, general ICU, or cardiovascular ICU in a tertiary teaching hospital.	In our hospital, during day time (08:00 to 16:59hr), the ICU team comprise three to four attending intensivists, two to three residents (critical care or other specialty fellows), and the average patient to nurse	The potential confounders affecting the association with in-hospital mortality included admission/ discharge time and weekend admission, P/N ratio, compliance with SSC 1 hour, severity of illness, age, gender, Charlson index, mechanical ventilation, and shock. The causal	<u>In-hospital mortality:</u> When the admission time was removed from the model, a significant association between P/N ratio and in-hospital mortality was found in four models in which different disease severity scores were adjusted.

		ratio (P/N ratio) is 2–3:1. In the other two time periods (17:00 to 23:59hr and 00:00 to 07:59hr), there is one senior intensivist, one resident, and the P/N ratio is 3–5:1. Imaging technical platform and surgical operating room are 24-hour available. Admissions may occur at any time of the day and night. This organization was maintained during the study period.	relationships between the potential confounders were considered seriously before multivariate logistic regression models. Multivariate models were fit using covariates found to be clinically relevant or significant in univariate analysis. Missing values of variables were imputed by multiple imputations.	Logistic regression models: Odds Ratio for In-Hospital Mortality by Patient to Nurse Ratio After Adjusting the Severity of the Illness: • Unadjusted model: OR=2.22 (1.78–2.78) • Adjusted for Acute Physiology Score III: OR=2.01 (1.57–2.61) • Adjusted for Sequential Organ Failure Assessment score: OR=1.98 (1.56–2.55) • Adjusted for Logistic Organ Dysfunction Score: OR = 2.04 (1.59–2.64 • Adjusted for Oxford Acute Severity of Illness Score: OR=2.06 (1.62–2.64)