Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of a Quality Improvement Intervention With Daily Round Checklists, Goal Setting, and Clinician Prompting on Mortality of Critically Ill Patients
A Randomized Clinical Trial

Writing Group for the CHECKLIST-ICU Investigators and the Brazilian Research in Intensive Care Network (BRICNet)

IMPORTANCE The effectiveness of checklists, daily goal assessments, and clinician prompts as quality improvement interventions in intensive care units (ICUs) is uncertain.

OBJECTIVE To determine whether a multifaceted quality improvement intervention reduces the mortality of critically ill adults.

DESIGN, SETTING, AND PARTICIPANTS This study had 2 phases. Phase 1 was an observational study to assess baseline data on work climate, care processes, and clinical outcomes, conducted between August 2013 and March 2014 in 118 Brazilian ICUs. Phase 2 was a cluster randomized trial conducted between April and November 2014 with the same ICUs. The first 60 admissions of longer than 48 hours per ICU were enrolled in each phase.

INTERVENTIONS Intensive care units were randomized to a quality improvement intervention, including a daily checklist and goal setting during multidisciplinary rounds with follow-up clinician prompting for 11 care processes, or to routine care.

MAIN OUTCOMES AND MEASURES In-hospital mortality truncated at 60 days (primary outcome) was analyzed using a random-effects logistic regression model, adjusted for patients' severity and the ICU's baseline standardized mortality ratio. Exploratory secondary outcomes included adherence to care processes, safety climate, and clinical events.

RESULTS A total of 6877 patients (mean age, 59.7 years; 3218 [46.8%] women) were enrolled in the baseline (observational) phase and 6761 (mean age, 59.6 years; 3098 [45.8%] women) in the randomized phase, with 3327 patients enrolled in ICUs (n = 59) assigned to the intervention group and 3434 patients in ICUs (n = 59) assigned to routine care. There was no significant difference in in-hospital mortality between the intervention group and the usual care group, with 1096 deaths (32.9%) and 1196 deaths (34.8%), respectively (odds ratio, 1.02; 95% CI, 0.82-1.26; P = .88). Among 20 prespecified secondary outcomes not adjusted for multiple comparisons, 6 were significantly improved in the intervention group (use of low tidal volumes, avoidance of heavy sedation, use of central venous catheters, use of urinary catheters, perception of team work, and perception of patient safety climate), whereas there were no significant differences between the intervention group and the control group for 14 outcomes (ICU mortality, central line–associated bloodstream infection, ventilator-associated pneumonia, urinary tract infection, mean ventilator-free days, mean ICU length of stay, mean hospital length of stay, bed elevation to ≥30°, venous thromboembolism prophylaxis, diet administration, job satisfaction, stress reduction, perception of management, and perception of working conditions).

CONCLUSIONS AND RELEVANCE Among critically ill patients treated in ICUs in Brazil, implementation of a multifaceted quality improvement intervention with daily checklists, goal setting, and clinician prompting did not reduce in-hospital mortality.

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Checklists have been proposed as tools to ensure that essential components of care are not omitted.[1-3] In intensive care units (ICUs), the use of checklists is associated with increased adherence to guidelines,[4] reduced rates of central line-associated bloodstream infection,[3,5] and earlier extubation.[6] Using checklists combined with daily goals assessment and clinician prompting may improve communication, adherence to care processes, and clinical outcomes.[7,8] However, the evidence supporting the use of checklists in critical care derives from before-after studies,[3,4,8] or studies aimed at specific conditions,[5] all conducted in high-income countries. Evidence from randomized trials is lacking,[9] akin to that for quality improvement (QI) interventions in general.[10]

Low- or middle-income countries such as Brazil sustain 85% of the global burden of critical illness.[11] In these settings, staff tend to operate under vertical, rather than horizontal, hierarchy, which contributes to a poor work climate and safety culture.[12,13] Perhaps as a consequence, adherence with guidelines is lower, and severity-adjusted outcomes are worse than in high-income countries.[14,15] Checklists, read out loud by team members, have successfully flattened hierarchy in a number of settings, improving work climate and process adherence.[7,8] We therefore hypothesized that such an approach would improve work climate, care processes, and mortality in Brazilian ICUs. Thus, we conducted a cluster randomized trial to assess the effect of a multifaceted QI intervention that promoted a daily checklist, goal setting during multidisciplinary rounds, and clinician prompts on in-hospital mortality of critically ill patients.

Methods

Study Design

The CHECKLIST-ICU study was conducted in 2 phases (**Figure 1**). Phase 1 was an observational study to assess baseline data on work climate, care processes, and clinical outcomes in Brazilian ICUs caring for adult patients. In phase 2, the ICUs were randomized to receive the multifaceted QI intervention or to routine care. The unit of concealed randomization was the ICU to minimize contamination, as we applied the intervention to the whole ICU multidisciplinary team. As part of the agreement to be included in the study, all ICUs randomized to control received the intervention after the study was completed.

The ethics committees of all institutions approved the study. The protocol and statistical analysis plan were published previously (see trial protocol in Supplement 1 and statistical analysis plan in Supplement 2).[16,17] To avoid selection bias, written consent was obtained at the cluster level from the director of each institution.[18] The funders had no role in the analysis or publication decision. Nevertheless, the funders and ICU leaders requested an intervention period not longer than 6 months so that ICUs randomized to the control group would also receive the intervention in a timely fashion.

Participants

Adult ICUs were included from all Brazilian regions. Pediatric ICUs, cardiac ICUs, step-down units, ICUs whose leadership did not or would not implement multidisciplinary daily rounds, and ICUs that already used checklists during rounds were excluded. When 2 or more ICUs from a single institution participated in the study, they were considered a single unit, except for those with completely separate teams. Intensive care units that successfully collected data in the observational phase (ie, inclusion of ≥30 patients within 6 months and collection of the Safety Attitudes Questionnaire [SAQ] from >75% of their staff) were randomized.

In both phases, ICUs enrolled between 40 and 60 consecutive patients 18 years or older with an ICU stay longer than 48 hours. Patients in whom a high probability of early death was anticipated (defined as death occurring between the 48th and 72nd hours of the ICU stay), patients receiving exclusive palliative care, and those with a suspected or confirmed diagnosis of brain death were excluded.

Randomization and Masking

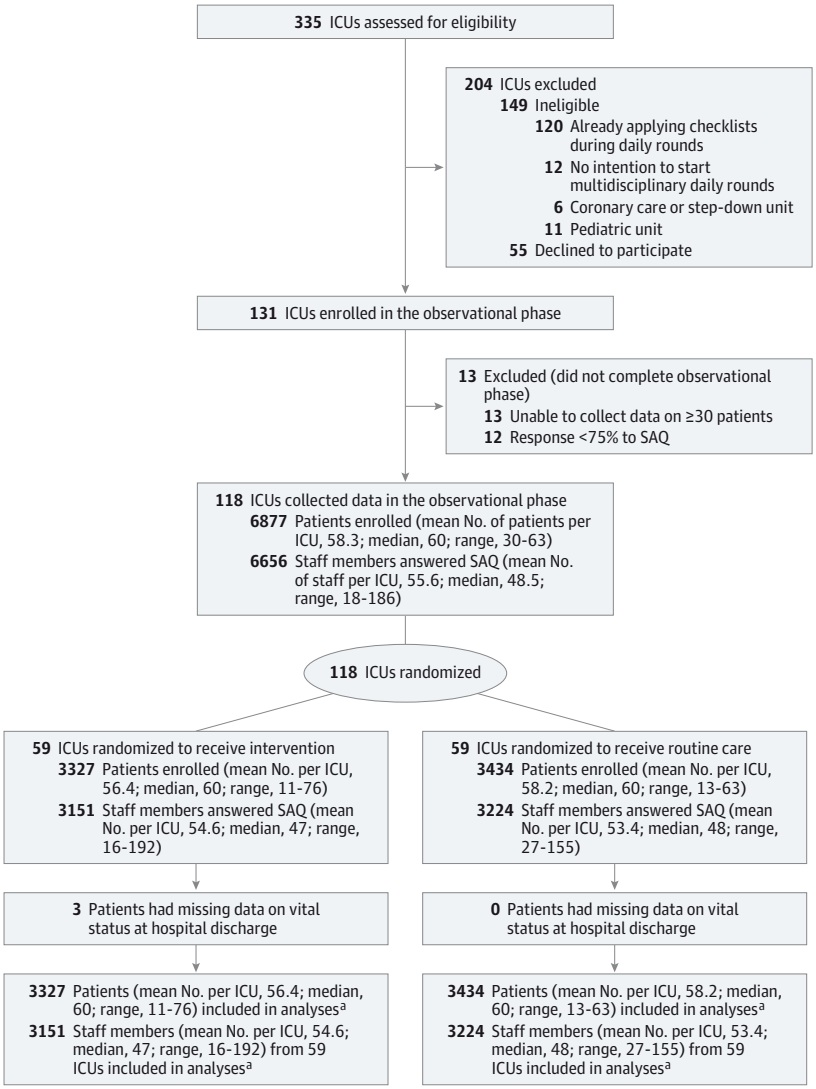
The units of randomization were the ICUs. A statistician from Research Institute HCor generated the randomization list with random permuted blocks of 4 units using an appropriate statistical package. Stratification was performed according to the median in-hospital mortality determined in the observational phase. To ensure allocation concealment, the statistician who prepared the list received only the identification code of the unit and was not aware of the identity of the ICU. The allocation list was then sent to the research manager, who informed the ICUs about their randomization status in January 2014.

Caregivers were not blinded to group assignment. Research coordinators and the statistician who analyzed the data were also not blinded, because data regarding adherence to checklist and clinician prompting were collected exclusively for the intervention group ICUs. Ventilator-associated pneumonia and central line-associated bloodstream infection diagnoses were adjudicated by a blinded committee using standardized definitions.[19,20]

Procedures

The intervention consisted of modifying daily multidisciplinary rounds to include the use of a checklist and discussion of goals of care, together with clinician prompting later in the day to ensure follow-through with checklist adherence and goals of care, for all patients during their entire ICU stay. The checklist (eFigure 1 in Supplement 3) was developed based on the clinical practice guideline development cycle.[21] It targeted 11 care processes aimed at prevention of venous thromboembolism (VTE), ventilator-associated pneumonia (head-of-bed ≥30°), central line-associated bloodstream, and urinary tract infection (removal of unnecessary urinary or venous catheters); improvement in nutrition and analgesia; reduction of sedation; assessment of readiness for extubation; detection of severe sepsis and acute respiratory distress syndrome; optimization of antibiotics (indication to start, adjust, or stop); and reduction of tidal volume.

Figure 1. Flow of Intensive Care Units and Patients Through the Trial Phases



In both phases, we did not collect data on patients who did not meet eligibility criteria. ICU indicates intensive care unit; SAQ, Safety Attitudes Questionnaire.

[a] We used multiple imputation to analyze primary outcome data.

A strategy to leverage the potential of the checklist was used, not only to avoid errors of omission, but also to promote a flat hierarchy by empowering the entire team to participate in daily rounds. Thus, during weekday rounds, the checklist was read aloud by a nurse and answered by participants. Daily goals were registered on a standardized form (eFigure 2 in Supplement 3) and then read aloud to the team. Every afternoon, a nurse reviewed the daily goals and prompted the on-call physician when there were pending items. The goal was that the intervention be applied at least on weekdays (Monday through Friday).

The following actions were taken to ensure adherence to the QI intervention (eTable 1 in Supplement 3): an investigators meeting; a visit of 1 member of the steering committee to every ICU to train the multidisciplinary team and participate in the rounds; audit and feedback on adherence to care processes; a study website; and dissemination of videos with testimonials of opinion leaders that focused on the importance of the study, and successful QI experiences, with special emphasis on the principle that the whole team works better than isolated voices. In addition, electronic text messages were sent every 2 to 3 days to the multidisciplinary team at the sites regarding adherence to the intervention, and ICU medical and nursing directors were contacted if adherence was low. Intensive care units started implementing the study intervention soon after the investigators meeting (March 14, 2014) and no later than March 31, 2014. Control group ICUs maintained routine care and received no preintervention training.

Outcomes

The primary outcome was in-hospital mortality, truncated at 60 days. Mortality was chosen as the primary outcome for several reasons. First, it is the most important outcome for critically ill patients and their relatives. Second, mortality is high among patients admitted to ICUs in Brazil. Third, previ-

ous before-after studies have suggested decreased mortality with the use of a surgical safety checklist[2] and clinician prompting in ICUs.[8]

Secondary exploratory outcomes were adherence to care processes, ICU safety climate, and clinical outcomes (eTable 2 in Supplement 3). Adherence to 7 care processes targeted by the checklist was measured: patients receiving enteral or parenteral feeding; head-of-bed elevated at 30° or more; patients receiving moderate to light sedation or alert and calm (Richmond Agitation-Sedation Scale score −3 to 0); mechanical ventilation tidal volume 8 mL/kg of predicted body weight or less; VTE prophylaxis; central venous catheter use; and indwelling urinary catheter use. Four items targeted by the checklist were not assessed due to feasibility constraints (timely screening of sepsis, adequacy of antibiotics, adequacy of analgesia, and daily spontaneous breathing trials). Six ICU safety climate domains (team work climate, safety climate, job satisfaction, stress recognition, perception of management, working conditions) were evaluated using the validated Brazilian-Portuguese version of the SAQ, administered anonymously to promote uninhibited answers.[22,23] Furthermore, the following clinical secondary outcomes were assessed: ICU mortality, mechanical ventilation-free days within 28 days, central line–associated bloodstream infection rate, ventilator-associated pneumonia rate, urinary tract infection rate, length of ICU stay, and length of hospital stay.

Trained research coordinators not involved in the care of ICU patients collected data prospectively in a web-based data capture system in both phases. Quality control was guaranteed by automated data entry checks, weekly contact with investigators, and central statistical checks.

Statistical Analysis

According to the sample size calculation, with 102 ICUs and an average of 50 patients per unit, the study had 90% power with a type I error rate of 5% to detect an absolute reduction in in-hospital mortality of 6% (from 30% in the control group to 24% in the intervention group), considering a coefficient of variation K of 0.25.[24] Baseline in-hospital mortality was estimated at 30% considering data of patients with an ICU stay longer than 48 hours from a large administrative database of Brazilian ICUs (Epimed Monitor System, Epimed Solutions). A 20% relative (6% absolute) risk reduction in mortality was considered to be a clinically relevant, biologically plausible, moderate effect size, and one typically observed in health care interventions.[25]

All analyses were prespecified and followed the intention-to-treat principle.[17] Because ICUs were randomized rather than patients and we measured outcomes at the patient level, the analyses were adjusted for clustering of the data. The primary outcome was analyzed using a prespecified random-effects logistic regression model, with adjustment for patients' Simplified Acute Physiology Score 3 (SAPS3) and for each ICU's standardized mortality ratio (calculated as the observed hospital mortality divided by that predicted from the SAPS3 observed in the observational phase) to account for potential baseline imbalances in patients' severity and ICUs' performance. Multiple imputation with chained equations was used for missing in-hospital vital status, assuming data were missing at random (mice package in R, R Foundation for Statistical Computing).[26] The imputation was conducted with 5 replicates using a logistic regression model with baseline covariates for sex and in-hospital mortality at the observational phase.

For all other analyses, the effect estimate was generated from a generalized linear mixed model that included a term for the observed outcomes within each ICU during the observational phase. Additional analyses included prespecified subgroups (2 strata of baseline in-hospital mortality [by median] observed for ICUs in the observational phase, public or private hospital, medical or surgical patient, 2 strata of the Sepsis-Related Organ Failure Assessment [SOFA] score, presence of sepsis at admission, and need for mechanical ventilation at admission) and subgroups defined a posteriori (academic or nonacademic hospitals, time of patients' enrollment at or before 60 days or after 60 days) using formal interaction tests.

All tests were 2-sided, and a P value lower than .05 denoted statistical significance. Prespecified secondary outcome analyses and subgroup analyses were not adjusted for multiple comparisons; thus, their results should be interpreted as exploratory. In post hoc sensitivity analyses, the significance level for secondary outcomes was adjusted using a Sidak correction, a method to control overall type I error when there are several independent hypothesis tests.[27] Analyses were performed with R version 2.10.1.

Results

Characteristics of Participants

The observational phase ran from September 2013 through March 2014, and the randomization phase ran from April 2014 through November 2014. A total of 335 ICUs accepted to participate; however, 149 were ineligible (120 were already applying checklists during daily rounds, 12 did not conduct and would not start multidisciplinary daily rounds, 6 were coronary care unit or step-down units, and 11 were pediatric units), and 55 eventually declined to participate. Thus, 131 ICUs were enrolled in the observational phase, of which 118 collected the required data and were randomized (59 in the intervention and 59 in the control group) (Figure 1). There were 11 ICUs located in the same hospitals, which were considered different units in the study. Only 1 hospital had ICUs allocated to different groups (2 ICUs assigned to intervention and 4 to control). Characteristics of the ICUs were similar between groups, although control ICUs had more beds and were more often located in academic hospitals (**Table 1**). Characteristics of ICUs not included in the randomized phase were similar to randomized ICUs (eTable 3 in Supplement 3).

A total of 13 638 patients in 118 ICUs were enrolled, including 6877 patients (mean age, 59.7 years; 3218 [46.8%] women) in the observational phase and 6761 in the random-

Table 1. Characteristics of Intensive Care Units

	Intervention Group (59 ICUs)	Control Group (59 ICUs)
No. of ICU beds, median (IQR)	11 (10-20)	14 (10-20)
Specialty, No. (%)		
Surgical	2 (3.4)	3 (5.0)
Medical	4 (6.8)	8 (13.6)
Mixed (medical and surgical)	50 (84.7)	44 (74.6)
Specialized	3 (5.1)	4 (6.8)
Hospital type, No. (%)		
Public	29 (49.2)	27 (45.8)
Private nonprofit	14 (23.7)	18 (30.5)
Private for-profit	16 (27.1)	14 (23.7)
Academic hospital, No. (%)[a]	13 (22.0)	26 (44.1)
No. of hospital beds, median (IQR)	157 (111-285)	239 (154-352)
Standardized mortality ratio at baseline, median (IQR)[b]	1.6 (1.1-2.2)	1.4 (0.9-1.9)

Abbreviations: ICU, intensive care unit; IQR, interquartile range.

[a] Defined as those that train graduate medical students.

[b] Standardized mortality ratio was calculated as the ratio between observed in-hospital mortality and the Simplified Acute Physiology Score 3–predicted in-hospital mortality in the observational phase.

ized phase (mean age, 59.6 years; 3098 [45.8%] women) (Figure 1). The mean duration each ICU was enrolled in the study was 4.4 months (median, 4.3; interquartile range [IQR], 3.7-5.0) and 4.5 months (median, 4.5; IQR, 3.5-5.4) in the control and intervention groups, respectively. The primary outcome was available for 6877 patients (100%) in the observational phase and 6758 patients (99.9%) in the randomized phase, although all patients were included in the primary outcome analyses. Responses to the SAQ were obtained from 6656 (85.3%) staff members in the observational phase and 6375 (78.8%) in the randomized phase, with response rates 75% or greater for 99.2% and 92.4% of ICUs, respectively, in both phases. Patient characteristics were similar between groups in both phases (**Table 2**). A total of 3435 (49.9%) and 3236 (47.9%) patients received mechanical ventilation in the observational and randomized phases, respectively.

QI Intervention Adherence

Multidisciplinary rounds occurred on 55.3 days per 100 patient-weekdays in the 118 ICUs in the observational phase. During the randomized phase, multidisciplinary rounds increased to 92.8 days per 100 patient-weekdays in intervention group ICUs,

Table 2. Characteristics of Patients in Observational and Randomized Phases

Characteristic	Observational Phase		Randomized Phase	
	Intervention Group (59 ICUs, 3437 Patients)	Control Group (59 ICUs, 3440 Patients)	Intervention Group (59 ICUs, 3327 Patients)	Control Group (59 ICUs, 3434 Patients)
Age, mean (SD), y	59.4 (19.3)	59.9 (18.8)	59.1 (19.2)	60.0 (18.8)
Female sex, No.(%)	1624 (47.3)	1594 (46.3)	1504 (45.2)	1594 (46.4)
Type of admission, No.(%)				
Medical	2413 (70.2)	2403 (69.8)	2424 (72.9)	2449 (71.4)
Elective surgery	629 (18.3)	539 (15.7)	539 (16.2)	503 (14.6)
Emergency surgery	395 (11.5)	498 (14.5)	361 (10.9)	482 (14.0)
Reason for ICU admission, No.(%)[a]				
Postoperative care	725 (21.1)	723 (21.0)	604 (18.1)	817 (23.7)
Respiratory failure (except sepsis)	620 (18)	473 (13.8)	575 (17.3)	494 (14.4)
After cardiorespiratory arrest	49 (1.4)	60 (1.7)	35 (1.1)	55 (1.6)
Neurological	399 (11.6)	477 (13.9)	403 (12.1)	442 (12.9)
Hepatic	50 (1.5)	42 (1.2)	47 (1.4)	61 (1.8)
Gastrointestinal	103 (3.0)	107 (3.1)	92 (2.8)	66 (1.9)
Sepsis	352 (10.2)	542 (15.8)	412 (12.4)	480 (14.0)
Shock (except sepsis)	38 (1.1)	49 (1.4)	35 (1.1)	40 (1.2)
Cardiovascular	438 (12.7)	320 (9.3)	432 (13.0)	346 (10.1)
Renal/metabolic	136 (4.0)	155 (4.5)	144 (4.3)	138 (4.0)
Hematological	19 (0.6)	23 (0.7)	31 (0.9)	39 (1.1)
Others	508 (14.8)	469 (13.6)	514 (15.5)	456 (13.3)
Comorbidities, No.(%)				
Cancer treatment, metastatic or hematological	192 (5.6)	345 (10)	218 (6.6)	357 (10.4)
Cirrhosis	62 (1.8)	85 (2.5)	87 (2.6)	87 (2.5)
Heart failure	202 (5.9)	257 (7.5)	231 (6.9)	232 (6.8)
AIDS	76 (2.2)	102 (3.0)	118 (3.5)	135 (3.9)
SAPS3 score at admission, mean (SD)[b]	50.6 (16.8)	54.2 (17.8)	51.2 (17.9)	54.2 (17.5)

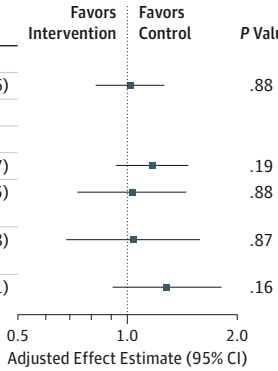
Abbreviations: ICUs, intensive care units; SAPS3, Simplified Acute Physiology Score 3.

[a] Only 1 main reason for ICU admission was assigned for each patient.

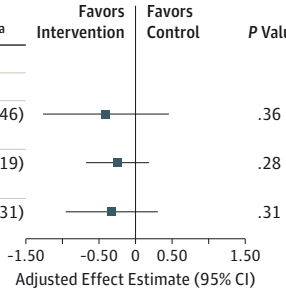
[b] SAPS3 is a score to assess severity of illness and to predict vital status at hospital discharge based on ICU admission data. SAPS3 values range from 0 to 217, with higher values indicating higher severity.

Figure 2. Effect of the Multifaceted Quality Improvement Intervention on Clinical Outcomes

	Intervention Group (59 ICUs, 3327 Patients)	Control Group (59 ICUs, 3434 Patients)	Effect Estimate Type	Adjusted Effect Estimate (95% CI)[a]	P Value
Primary outcome					
In-hospital mortality, No./total No. of patients (%)[b]	1096/3327 (32.9)	1196/3434 (34.8)	Odds ratio	1.02 (0.82 to 1.26)	.88
Secondary exploratory outcomes					
Clinical outcomes					
ICU mortality, No./total No. of patients (%)	874/3324 (26.3)	871/3434 (25.4)	Odds ratio	1.17 (0.93 to 1.47)	.19
Catheter-related bloodstream infection, No. per 1000 patient-days/total No. of patient-days (%)	143/17 286 (8.3)	153/18 475 (8.3)	Rate ratio	1.03 (0.73 to 1.45)	.88
Ventilator-associated pneumonia, No. per 1000 patient-days/total No. of patient-days (%)	64/11 823 (5.4)	65/13 569 (4.8)	Rate ratio	1.04 (0.68 to 1.58)	.87
Urinary tract infection, No. per 1000 patient-days/total No. of patient-days (%)	158/14 975 (10.6)	151/18 954 (8.0)	Rate ratio	1.28 (0.91 to 1.81)	.16



	Intervention Group (59 ICUs, 3324 Patients)	Control Group (59 ICUs, 3434 Patients)	Effect Estimate Type	Adjusted Effect Estimate (95% CI)[a]	P Value
Secondary exploratory outcomes					
Clinical outcomes					
Ventilator-free days in a 28-day period, mean (95% CI)	13.0 (12.8 to 13.2)	13.4 (13.2 to 13.6)	Mean difference	-0.40 (-1.26 to 0.46)	.36
ICU length of stay, mean (95% CI), d	10.2 (9.8 to 10.6)	10.4 (10.1 to 10.7)	Mean difference	-0.24 (-0.67 to 0.19)	.28
Hospital length of stay, mean (95% CI), d	18.7 (18.2 to 19.2)	20.0 (19.4 to 20.6)	Mean difference	-0.32 (-0.95 to 0.31)	.31



[a] All effect estimates were adjusted for baseline values of outcome variables, except in-hospital mortality odds ratio, which was adjusted for baseline values of intensive care units' (ICUs') standardized mortality rate (calculated with Simplified Acute Physiology Score 3 [SAPS3]) and patients' SAPS3.

[b] The intracluster correlation coefficient calculated from a random-effects model for the primary outcome was 0.13, and the coefficient of variation *K* was 0.25.

compared with 61.5 days per 100 patient-weekdays in control ICUs ($P < .001$). In the intervention group, the checklist was applied on 90.6 days per 100 patient-weekdays and clinician promptings on 89.1 days per 100 patient-weekdays.

Primary Outcome

In the observational phase, in-hospital mortality was 32.5%, whereas the SAPS3-predicted risk was 27.1%. Intensive care unit mortality was 25.0%. Rates of central line–associated bloodstream infection, ventilator-associated pneumonia, and urinary tract infection were 7.4, 4.3, and 10.6 cases per 1000 patient-days, respectively. The mean (SD) lengths of ICU stay and hospital stay were 10.6 (11.2) days and 19.8 (16.6) days, respectively. Among patients receiving mechanical ventilation, the mean (SD) number of days receiving ventilator was 8.1 (9.3), and they had a mean (SD) 13.2 (7.7) ventilator-free days in 28 days.

In the randomized phase, there were 1096 in-hospital deaths among 3327 patients (32.9%) in the intervention group and 1196 deaths among 3434 patients (34.8%) in the control group (adjusted odds ratio [OR], 1.02; 95% CI, 0.82 to 1.26; $P = .88$) (**Figure 2** and eTable 4 in Supplement 3). The between-group adjusted difference for in-hospital mortality was 0.39% (95% CI, −3.70 to 4.47; $P = .84$).

Secondary Outcomes

Clinical Outcomes

The QI intervention had no effect on secondary exploratory clinical outcomes: ICU mortality, central line–associated bloodstream infection, ventilator-associated pneumonia, urinary tract infection, mean ventilator-free days, mean days receiving mechanical ventilation, and mean ICU or hospital length of stay (Figure 2 and eTable 4 in Supplement 3).

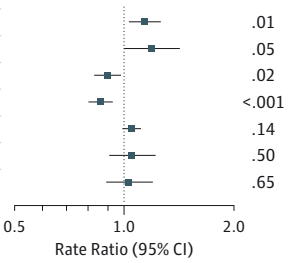
Care Processes

Adherence varied across the 7 exploratory outcomes reflecting care processes during the observational phase (eTable 4 in Supplement 3). For only 36.1% of the total patient-days, patients received a moderate level of sedation or were alert and calm, and on 54.1% of patient-days, patients received a tidal volume of 8 mL/kg of predicted body weight or less. Head-of-bed was elevated 30° or more on 90.3% and VTE prophylaxis was adequate on 70.1% of patient-days. Central venous lines and urinary catheters were used on 74.1% and 73.2% of patient-days, respectively.

The QI intervention improved adherence for the 4 care processes that had poor baseline adherence: increased use of low tidal volume (67.5% vs 58.9% of patient-days; adjusted rate ratio [RR], 1.14; 95% CI, 1.03-1.26; $P = .01$) and

Figure 3. Effect of the Multifaceted Quality Improvement Intervention on Processes of Care

	Intervention Group (59 ICUs, 3327 Patients)	Control Group (59 ICUs, 3434 Patients)	Rate Ratio (95% CI)[a]	P Value
Processes of care, No. of patient-days used/total No. of patient-days (%)				
Tidal volume ≤8 mL/kg of predicted body weight	3012/4459 (67.5)	3031/5149 (58.9)	1.14 (1.03-1.26)	.01
Moderate sedation to alert and calm (RASS -3 to 0)	1805/4462 (40.5)	1800/5149 (35.0)	1.19 (1.00-1.42)	.05
Central venous catheter use	17 286/23 861 (72.4)	18 475/25 329 (72.9)	0.90 (0.83-0.98)	.02
Urinary catheter use	14 975/23 861 (62.8)	18 954/25 329 (74.8)	0.86 (0.80-0.93)	<.001
Head-of-bed elevated ≥30°	7129/7460 (95.6)	7071/7882 (89.7)	1.05 (0.99-1.11)	.14
Prophylaxis for venous thromboembolism	6963/9306 (74.8)	7339/9781 (75.0)	1.05 (0.91-1.22)	.50
Diet administration	7374/9306 (79.2)	7468/9781 (76.4)	1.03 (0.89-1.20)	.65



RASS indicates Richmond Agitation-Sedation Scale.

[a] All effect estimates were adjusted for baseline values of outcome variables.

Table 3. Effect of the Multifaceted Quality Improvement Intervention on Safety Climate Secondary Exploratory Outcomes[a]

Secondary Exploratory Outcome	No. of Positive Answers/No. of Staff (%)		Intervention vs Control		P Value
	Intervention Group	Control Group	Adjusted Odds Ratio (95% CI)[b]	Adjusted Difference, % (95% CI)[b]	
Team work climate	1683/3130 (53.8)	1471/3212 (45.8)	1.30 (1.08 to 1.57)	6.5 (1.9 to 11.2)	.01
Safety climate	1142/3128 (36.5)	1024/3214 (31.9)	1.27 (1.02 to 1.57)	5.4 (0.4 to 10.5)	.03
Job satisfaction	2362/3143 (75.2)	2254/3215 (70.1)	1.10 (0.87 to 1.39)	2.0 (−3.0 to 6.4)	.41
Stress recognition	1609/3133 (51.4)	1733/3206 (54.1)	0.92 (0.75 to 1.12)	−2.1 (−7.2 to 2.8)	.39
Perception of management	685/3116 (22.0)	587/3196 (18.4)	1.14 (0.90 to 1.45)	2.0 (−1.5 to 6.2)	.26
Working conditions	1475/3125 (47.2)	1346/3209 (41.9)	1.18 (0.96 to 1.45)	4.1 (−1.0 to 9.2)	.11

[a] Safety climate was assessed with the validated Brazilian-Portuguese version of the Safety Attitudes Questionnaire (SAQ), which has 36 items divided into 6 domains (teamwork climate, safety climate, job satisfaction, stress recognition, perception of management, and working conditions). Each item is measured on a 5-point Likert scale (disagree strongly, disagree slightly, neutral, agree slightly, and agree strongly). For an answer to count as positive for a given domain, the survey respondent must answer, on average, "agree slightly" or "agree strongly" to all related items.

[b] All effect estimates were adjusted for baseline values of outcome variables.

patient-days receiving light sedation or alert and calm among patients under mechanical ventilation (40.5% vs 35.0% of patient-days; adjusted RR, 1.19; 95% CI, 1.00-1.42; $P = .05$) and decreased use of central venous catheters (72.4% vs 72.9% of patient-days; adjusted RR, 0.90; 95% CI, 0.83-0.98; $P = .02$) and urinary catheters (62.8% vs 74.8% of patient-days; adjusted RR, 0.86; 95% CI, 0.80-0.93; $P < .001$) (**Figure 3** and eTable 4 in Supplement 3). The QI intervention did not affect the 3 care processes with better baseline adherence (bed elevation to ≥30° [95.6% vs 89.7% of patient-days; adjusted RR, 1.05; 95% CI, 0.99-1.11; $P = .14$]; VTE prophylaxis [74.8% vs 75.0% of patient-days; adjusted RR, 1.05; 95% CI, 0.91-1.22; $P = .50$]; and diet administration [79.2% vs 76.4% of patient-days; adjusted RR, 1.03; 95% CI, 0.89-1.20; $P = .65$]) (Figure 3 and eTable 4 in Supplement 3).

Safety Climate

At baseline, the percentages of positive answers for exploratory SAQ domains were 47.9% for teamwork climate, 32.5% for safety climate, 72.5% for job satisfaction, 54.7% for stress recognition, 20.7% for management perception, and 45.6% for work conditions. There were significant differences between groups in teamwork and safety climate by the end of the randomization phase. In the intervention group, 53.8% of staff answered that teamwork climate was positive, compared with 45.8% in the control group (adjusted OR, 1.30; 95% CI, 1.08-1.57; $P = .01$) (**Table 3** and eTable 4 in Supplement 3). In the intervention group, 36.5% of staff answered that safety climate was positive, compared with 31.9% in the control group (adjusted OR, 1.27; 95% CI, 1.02-1.57; $P = .03$). There were no differences between groups in the other SAQ domains. The effects on all secondary outcomes were not significant after adjustment for multiple comparisons, except for a reduction in the use of urinary catheters (Sidak-corrected significance level, .002).

Exploratory Subgroup and Ancillary Analyses

There was no significant heterogeneity in the intervention effect on in-hospital mortality in the predefined subgroups of patients with higher or lower baseline in-hospital mortality; public, private nonprofit, or private for-profit hospitals; need for mechanical ventilation at admission or not; medical or surgical admission; lower or higher SOFA score; or presence of sepsis at admission or according to SAPS3 decile (eTable 5 in Supplement 3). However, in exploratory analyses not adjusted for multiple comparisons, the effects of the QI intervention on in-hospital mortality were significantly different

according to baseline levels of safety climate and perception of management (eTable 5 in Supplement 3).

Because there was imbalance in the number of academic hospitals between groups, a post hoc analysis was conducted to assess the effect of the intervention on outcomes in the subgroup of academic vs nonacademic ICUs. Effects on in-hospital mortality, care processes, and SAQ domains were similar (all *P* values for interaction >.05) between academic and nonacademic hospitals. Additional post hoc analysis was conducted to assess whether the effect on mortality might differ among patients included earlier (within 60 days from the inclusion of the first patients in a given ICU) vs later in the randomized phase (>60 days since the inclusion of the first patient in a given ICU). There was no interaction between treatment effect on mortality and time of enrollment (enrolled ≤60 days: OR, 1.05; 95% CI, 0.81-1.36; enrolled >60 days: OR, 0.94; 95% CI, 0.68-1.3; *P* value for interaction = .42).

Discussion

In this study of Brazilian ICUs, the introduction of daily checklists, goal setting, and clinician prompting did not decrease in-hospital mortality or other clinical outcomes. The large numbers of clusters included and events observed allowed us to reliably exclude a moderate to large effect on mortality (≥6% absolute reduction). In addition, potential improvements were observed in 4 of 7 care processes and 2 safety climate domains, although except for 1 outcome, urinary catheter use, these findings were not significant after adjustment for multiple comparisons.

Several potential explanations were considered for the lack of effect on mortality. First, although adherence to the QI intervention was adequate, the effect on care processes was modest and questionable due to the multiple unadjusted comparisons. Second, it is possible that the intervention needs time to work and our observation period was too short. Although there was a signal suggesting improvement in care processes and safety culture, a longer intervention period might have led to a more horizontal hierarchy, greater trust and teamwork, and ultimately demonstrable effects on patient outcomes.[3,5] However, both the government funder and local clinical leaders stipulated the short duration so that control ICUs could receive the intervention quickly. Third, it is possible that the items on the checklist have very modest or negligible effects on mortality. Although all the care processes included in the checklist used in this study are recommended by guidelines, most have uncertain effects on mortality.[28-32] For example, care processes such as semirecumbent position and VTE prophylaxis may decrease adverse events but have no proven effect on mortality.[33,34]

Studies assessing checklists or clinician prompting have found contradictory results. Some suggest marked improvements on adherence to care processes and clinical outcomes,[2-5,8] while others found limited[35] or no effect[2,36] on care processes. A systematic review of 9 before-after studies of safety checklists in acute care found inconsistent improvements in patient safety.[9] These studies differ in several ways. Haynes et al[2] showed reductions in complication rates and mortality with the implementation of a checklist during surgery, but the study involved a different population. In addition, this and other studies involving critically ill patients were simplistic before-after studies, subject to bias by secular trends.[2-4,8,9] Indeed, the replication of either the safe surgery checklist in Ontario[37] or the checklist to prevent central line infections in England[36] did not change complications, infections, or deaths. Other studies using a cluster randomized design similar to that of the current study assessed different outcomes and interventions.[5,35] Marsteller et al[5] evaluated a multifaceted intervention exclusively focused on preventing catheter-related bloodstream infections. Scales et al[35] tested the effectiveness of a QI program to improve adherence to 6 care processes, although checklists were used only during central line insertion. Thus, the robust assessment of the effects of daily round checklists and clinician prompting in a randomized trial is a unique feature of the current study.

This study has several strengths. Over a relatively short time frame, a countrywide government-sponsored initiative with modest funding was able to successfully introduce and assess the effects of a multifaceted QI intervention. The trial was large, and the cluster randomization worked well, with a good balance of baseline characteristics between the 2 groups. The intervention was effectively deployed, and all relevant data were captured, including high response rates from staff, both in the observational and randomized phases. Bias was minimized through allocation concealment and through independent data collection by staff uninvolved with patient care. Furthermore, this study is one of the first of this scale to be conducted in an intensive care setting in a middle-income country, demonstrating important proof of feasibility.

This study also has several limitations. The duration of intervention was limited. In addition, restricting the sample to patients with more than 48 hours of ICU stay may have lead to a theoretical risk of imbalance between groups. Nevertheless, baseline characteristics were well balanced. Moreover, the care processes addressed in the checklist (eg, VTE prophylaxis or semirecumbent position) were unlikely to benefit those who were discharged early from the ICU or to prevent early deaths. Information on excluded patients or on discharge location for survivors was not collected, although hospital discharge to locations other than home is rare in Brazil. Four items targeted by the checklist were not assessed because of feasibility constraints. Qualitative assessments of the root causes of a suboptimal safety climate were not conducted. In addition, these results may not be applicable to settings with different baseline levels of safety climate.

Conclusions

Implementation of a multifaceted QI intervention with daily checklists, goal setting, and clinician prompting did not reduce in-hospital mortality compared with routine care among critically ill patients treated in ICUs in Brazil.

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