Dissemination of the Canadian clinical practice guidelines for nutrition support: Results of a cluster randomized controlled trial

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Objective: **To compare the effectiveness of active to passive dissemination of the Canadian clinical practice guidelines (CPGs) for nutrition support for the mechanically ventilated critically ill adult patient.**

Design: **A cluster-randomized trial with a cross-sectional outcome assessment at baseline and 12 months later.**

Setting: **Intensive care units in Canada.**

Patients: **Consecutive samples of mechanically ventilated patients at each time period.**

Interventions: **In the active group, we provided multifaceted educational interventions including Web-based tools to dietitians. In the passive group, we mailed the CPGs to dietitians.**

Measurements and Main Results: **The primary end point of this study was nutritional adequacy of enteral nutrition; secondary end points measured were compliance with the CPGs, glycemic control, duration of stay in intensive care unit and hospital, and 28-day mortality. Fifty-eight sites were randomized. At baseline and follow-up, 623 and 612 patients were evaluated. Both groups were well matched in site and patient characteristics. Changes in enteral nutrition adequacy between the active and passive arms were similar (8.0% vs. 6.2 %, $p = .54$). Median time spent in the target glucose range increased 10.1% in the active compared with 1.8% in the passive group ($p = .001$). In the subgroup of medical patients, enteral nutrition adequacy improved more in the active arm compared with the passive group (by 8.1%, $p = .04$), whereas no such differences were observed in surgical patients. When groups were combined, during the year of dissemination activities, there was an increase in enteral nutrition adequacy (from 43% to 50%, $p < .001$), an increase in the use of feeding protocols (from 64% to 76%, $p = .03$), and a decrease in patients on parenteral nutrition (from 26% to 21%, $p = .04$). There were no differences in clinical outcomes between groups or across time periods.**

Conclusions: **Although active dissemination of the CPGs did improve glycemic control, it did not change other nutrition practices or patient outcomes except in a subgroup of medical patients. Overall, dissemination of the CPGs improved other important nutrition support practices but was not associated with improvements in clinical outcomes. (Crit Care Med 2006; 34:2362–2369)**

KEY WORDS: nutrition support; enteral nutrition; critical care; clinical practice guidelines; cluster randomized trials; intensive care units

Despite the evidence that nutrition support interventions influence the outcomes of critically ill patients (1–4), several studies have documented variations in practice and inadequate delivery of enteral nutrition (EN) (5–8). In a cross-sectional survey of nutrition support practices in 702 patients across 66 Canadian intensive care units (ICUs) (7), 40% of patients received no form of nutrition support. Of those who did receive some form of nutritional support, on average, patients received only 58% of their prescribed calories and protein. Furthermore, the use of strategies to maximize the benefit and minimize the risks associated with EN was suboptimal. Only half of ICUs used an enteral feeding algorithm, small bowel feedings and motility drugs were underused, and >50% of patients had their head of bed at <30°.

The development and dissemination of evidence-based clinical practice guidelines (CPGs) are considered to be one strategy to reduce variation and improve practice (9). We developed detailed, evidence-based CPGs to facilitate more effective, efficient, and consistent delivery of nutrition support to critically ill patients (10). We validated these CPGs in an observational study and demonstrated that sites whose practices were more compliant with the CPGs had a greater adequacy of EN than those that were less compliant (11). The next step was to attempt to narrow the gap between best practice (as defined by the CPGs) and current practice (as defined by our survey results) by effective dissemination of these CPGs.

In developing our dissemination strategies, we considered existing studies outside the ICU setting which suggested that passive methods of implementing guidelines by publication in professional journals or mailing to health care professionals rarely lead to changes in professional

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Web based tools and training kits are available at www.criticalcarenutrition.com.

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behavior (12–14). Multifaceted interventions targeting different barriers to change have been shown to be more effective than single interventions (15, 16). However, the applicability of these findings to the critical care setting and which of the proposed behavior change strategies are most effective in the ICU are unknown (17). There are sparse data suggesting that guidelines and guideline implementation strategies improve the processes (18–20), outcomes (21, 22), and costs (19, 21) of caring for critically ill patients. In the context of critical care nutrition, preliminary evidence from a cluster randomized controlled trial demonstrated that active dissemination of an evidence-based feeding protocol, when compared with a passive approach, may lead to improvements in practice and clinical outcomes (21).

Our objective was to compare the effectiveness of a multifaceted dissemination strategy that included Web-based tools and an interactive workshop to passive dissemination of CPGs for nutrition support. The hypothesis was that active dissemination of the CPGs with multifaceted strategies would lead to more favorable changes in nutrition support practice and patient outcomes compared with passive dissemination.

METHODS

Participants

Canadian ICUs with at least eight beds and a dietitian were eligible for this study. We identified 79 ICUs meeting the eligibility criteria; 59 agreed to participate. Our ICU at the Kingston General Hospital was excluded to avoid the risk of contamination. Of the remaining 58 ICUs, 12 shared staff and procedures with other participating ICUs. To reduce contamination across units (23), we grouped these ICUs into distinct clusters resulting in a total of 50 clusters (24). The clusters were stratified according to size ($\leq$12 beds and $>$12 beds) and setting (academic vs. community) and then randomized to either active or passive dissemination strategies. Randomization was computer generated and blinding was not possible.

To collect data on nutrition support practices and patient outcomes, we conducted a cross-sectional survey at baseline (before the randomization) and 1 yr later. On May 7, 2003, all mechanically ventilated ICU patients who remained in the ICU for $>$72 hrs were enrolled, and the same sampling strategy was repeated on May 5, 2004. Sites with less than ten eligible patients in the ICU on the day of data collection were asked to collect data on consecutive admissions until a minimum of ten patients at their site were enrolled. Following the baseline data collections, sites were randomized and dietitians in the active sites were instructed to begin their educational interventions.

Interventions

Our strategies to change practice were developed and organized around two conceptual models describing the process of acquiring knowledge and translating that information into practice. The first model marks progress from awareness, through agreement and adoption, to adherence with evidence-based practice (25), whereas the second model focuses on health promotion in the educational system and is based on elements such as predisposition, enabling, and reinforcement (26). The combination of these two models has been used to illustrate how knowledge translation works in closing the gap between evidence and practice (27) (Table 1).

In the active dissemination arm, we positioned study dietitians as local opinion leaders who would lead change initiatives at each site (28). We provided password-protected access to a Web site (www.criticalcarenutrition.com) with access to the CPGs, supporting documents, educational tools (nutrition algorithms including an evidence-based feeding protocol, flowsheets, sample order sheets), and training kits to assist the dietitians in their leadership role. Dietitians were instructed to implement an enteral feeding protocol or modify their existing one to reflect the evidence-based recommendations. Posters and pocket cards that summarized the recommendations from the CPGs were also distributed to the sites. Data collected at baseline were used to generate a site-specific benchmarking report that compared a site's current practice to other sites and also to the CPGs, a form of audit and feedback (29). Each dietitian was instructed to conduct at least one interactive workshop with relevant ICU staff, to review the site reports, discuss the site's strengths and weaknesses in current practice, and formulate strategies to improve practice. Dietitians were encouraged to conduct ongoing audits of their change strategies to affirm that appropriate changes were occurring. Through periodic outreach activities at national meetings and *ad hoc* conference calls, project staff contacted study dietitians to provide support, training, and advice.

In the passive arm, we mailed a copy of the CPGs to study dietitians. They were not provided any tools or training and were left to implement the guidelines consistent with their usual practice.

Outcomes

The primary end point of this study was nutritional adequacy of EN defined as the calories received from EN divided by the maximum total daily calories prescribed (recommended by the dietitian) for each individual patient during the first 12 days of ICU stay. This was based on the observation from two randomized trials which demonstrated that improvements to nutrition support practice resulted in increased adequacy of EN and translated into improved clinical outcomes (21, 30). For the primary end point only, we conducted two *a priori* subgroup analyses in

Table 1. Model for knowledge translation

	Perspective of Target			
Intervention	Awareness	Agreement	Adoption	Adherence
Predisposing	Distribution of CPGs Posters Pocket cards Access to Web site Manuals Protocols/ algorithm			
Enabling		Opinion leaders Academic detailing teleconference	Interactive workshop Small group session Audit and feedback Site Reports	
Reinforcing				Reminders via email Site reports

CPG, clinical practice guidelines.
Specific interventions used in our study based on theoretical models for changing behavior.

academic vs. community ICUs and medical vs. surgical patients. Secondary end points measured were compliance with the CPGs, glycemic control, duration of ICU and hospital stay, and 28-day mortality rate. Laboratory surrogate end points were not studied.

Dietitians in both groups collected the data and completed the electronic case report forms. The head of the bed elevation was obtained from direct patient observation. On study completion, dietitians completed a questionnaire identifying guideline dissemination activities that occurred in both groups.

Sample Size

Our initial power estimates assumed that we would enlist ≥50 eligible clusters with at least 10 patients each. Based on data from our previous observational study (7), we estimated a between-subject SD of 26% and an intracluster correlation coefficient of .26 for our primary end point. Thus, the relative efficiency of this study compared with a simple randomized trial was estimated to be about 30%, yielding an effective sample size of 75 patients per group (31). Using an independent Student's *t*-test at a two-sided 5% significance level, our projected sample size would provide 80% power to detect an absolute between-group difference of 12% in nutritional adequacy by EN.

Statistical Methods

For each outcome, the change from baseline to follow-up was compared between the active and passive group by estimating the interaction between the period and group effects. To account for the trial's cluster design, continuous outcomes were analyzed using a linear mixed model with a random intercept for cluster as implemented by the MIXED procedure of SAS version 8.2 software (SAS Institute, Cary, NC) (32), and dichotomous outcomes were analyzed using a two-level hierarchical model as implemented in HLM 5.04 (33). Estimates for 12-day nutritional adequacy were adjusted for ICU length of stay so that the reported estimates (mean ± SE) represent the expected average nutritional adequacy during the first 12 days of ICU study. Daily average glucose was calculated by averaging the daily averages during the study duration. The proportion of time within glucose target range (4.4–6.1) was estimated for each patient by linear interpolation between consecutive measures. The hyperglycemic index was defined as the area under the curve above 6.1 mmol/L divided by the observation time (34). Although all three glucose measures are reported as raw medians with interquartile ranges, the *p* values are based on the mixed model. The *p* values for the between-group comparisons of hospital stay and ICU stay were derived from a Fisher's randomization test of the log-rank statistic (35). All tests were performed at a two-sided .05 significance level. Secondary end points were considered exploratory and hypothesis generating so no adjustments were made for the multiplicity tests. Statisticians at the Clinical Evaluation Research Unit at the Kingston General Hospital analyzed the data.

Ethics

Ethics approval was obtained from Queen's University and all participating sites that required approval. The need for informed consent was waived except for one site that required informed consent from all participating patients.

RESULTS

Participant Flow

A total of 58 sites were grouped into 50 clusters (25 clusters in each arm) and were included in the analysis (Fig. 1). There were 623 patients accrued at baseline and 612 patients at follow-up 1 yr later. Patients were observed for an average of 10.6 days (range 3–12). Site and patient characteristics were well balanced (Tables 2 and 3).

In the active group, 84% (21 of 25) of clusters held an interactive workshop vs. 16% (4 of 25) of clusters in the passive group. Adoption or revisions to feeding protocols were made in 50% (13 of 25) of clusters in the active group vs. 28% (7 of 25) in the passive group. Nine of 25 (36%) of dietitians in the active group conducted audits of their practice during the study period compared with 0 of 25 in the passive group.

Active Versus Passive

Primary Outcome. The intraclass correlation coefficient, which describes the proportion of variance attributable to the clusters, was .11 ($p < .001$). Both groups experienced a significant increase from the baseline to follow-up (passive, 45.2% to 51.3%, $p = .005$; active, 40.7% to

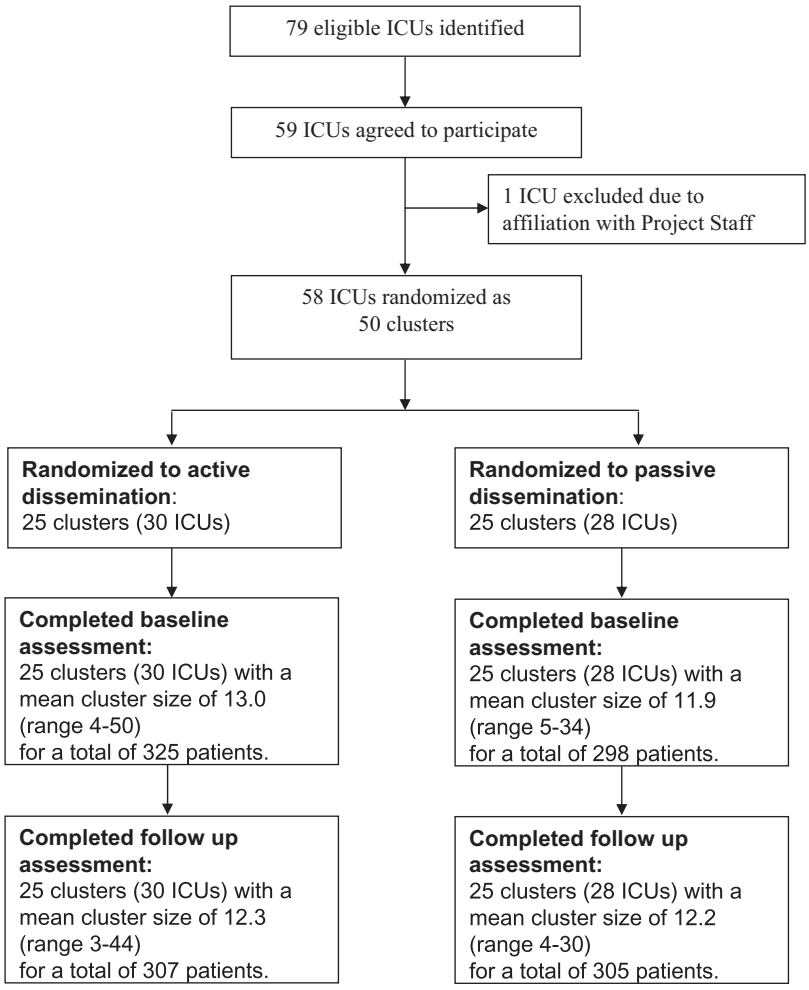

Figure 1. Flow diagram of participants. All 50 clusters and their contributed patients were analyzed as randomized. *ICU,* intensive care unit.

Table 2. Site characteristics

Characteristic	Passive Group (n = 25)	Active Group (n = 25)
Hospital type, n (%)		
Academic	13 (52)	12 (48)
Community	12 (48)	13 (52)
ICU beds, mean (range)	17.3 (7–59)	18.8 (8–83)
ICU type, n (%)		
Open	4 (16)	5 (20)
Closed	21 (84)	18 (72)
Other	0	2 (8)
Presence of medical director, n (%)	25 (100)	23 (92)
Hospital size, mean (range)	452 (137–1155)	517 (131–2615)
% FTE RD per ICU bed, mean (range)	4.8 (2.5–10)	3.9 (1–6.3)
Case mix, n (%)		
Medical	23 (92)	24 (96)
Surgical	24 (96)	24 (96)
Trauma	14 (56)	11 (44)
Neurologic	18 (72)	15 (60)
Cardiac surgery	8 (32)	7 (28)
Neurosurgical	10 (40)	7 (28)
Burns	8 (32)	8 (32)
Pediatrics	5 (20)	5 (20)
Other	4 (16)	7 (28)

ICU, intensive care unit; FTE RD, full-time equivalent registered dietitian.

Table 3. Patient characteristics

	Baseline		Follow-Up	
Characteristic	Passive	Active	Passive	Active
Males, n (%)	187 (63)	191 (59)	168 (55)	173 (56)
Age, mean (range)	61 (17–90)	62 (15–94)	63 (16–95)	62 (16–91)
BMI, mean (range)	27 (14–59)	28 (11–65)	28 (15–93)	27 (12–74)
Admission category, n (%)				
Medical	148 (50)	189 (58)	178 (58)	171 (56)
Elective surgical	73 (25)	74 (23)	45 (15)	45 (15)
Emergency surgical	77 (26)	62 (19)	82 (27)	91 (30)

BMI, body mass index.

Table 4. Primary outcome—Nutritional adequacy by enteral nutrition

Group	Arm	Baseline	Follow-Up	Change	*p* Value
All Patients	Passive	45.2 ± 2.5	51.3 ± 2.6	6.2 ± 2.2	.005
n_{sites} = 50	Active	40.7 ± 2.5	48.7 ± 2.6	8.0 ± 2.1	<.001
$n_{patients}$ = 1,235	Difference (A − P)	−4.5 ± 3.5	−2.6 ± 3.5	1.9 ± 3.1	.541
	Average (A + P)	42.9 ± 1.8	50.0 ± 1.9	7.1 ± 1.5	<.001
Medical	Passive	55.7 ± 2.8	57.6 ± 2.7	1.9 ± 2.8	.507
n_{sites} = 49	Active	48.5 ± 2.7	58.5 ± 2.8	10.0 ± 2.7	<.001
$n_{patients}$ = 686	Difference (A − P)	−7.2 ± 3.8	1.0 ± 3.7	8.1 ± 3.9	.036
	Average (A + P)	52.1 ± 2.0	58.0 ± 2.1	6.0 ± 2.0	.003
Surgical	Passive	33.8 ± 3.2	40.9 ± 3.4	7.0 ± 3.1	.025
n_{sites} = 50	Active	29.9 ± 3.4	35.5 ± 3.4	5.6 ± 3.2	.077
$n_{patients}$ = 549	Difference (A − P)	−3.9 ± 4.6	−5.3 ± 4.7	−1.5 ± 4.4	.744
	Average (A + P)	31.9 ± 2.4	38.2 ± 2.5	6.3 ± 2.2	.005

A, active arm; P, passive arm; difference (A − P), difference between arms; average (A + P), average of the two arms.

Values are mean ± SE.

48.7%, $p < .001$), but this improvement was not significantly different between groups (difference in change 1.9 ± 3.1%, $p = .54$). However, in the subgroup of medical patients, there was a greater increase in EN adequacy for the active dissemination group (difference in change, 8.1 ± 3.9%; $p = .036$), which was not seen in the surgical patients (difference in change, −1.5 ± 4.4%; $p = .74$) (Table 4). Between the active and passive groups, there were no differences in the change in adequacy of EN in community (difference in change, 3.4 ± 5.0%; $p = .49$) or academic hospitals (difference in change, 0.7 ± 3.9%; $p = .85$). Daily adequacy is shown in Figure 2.

Secondary Outcomes. The median daily average glucose levels decreased from 8.1 to 7.7 in the intervention arm and from 8.2 to 8.1 in the control arm ($p = .003$ for difference in change). The median proportion of ICU stay with glucose between 4.4 and 6.1 increased 10.1% in the active compared with 1.8% in the passive arm ($p = .001$). The median hyperglycemic index >6.1 decreased by 0.3 more in the active arm ($p = .003$). A sensitivity analysis demonstrated that all conclusions regarding the three glycemic control variables remained the same under the log and rank transformations. There were no other significant differences with nutrition support practices between groups (Table 5).

The average maximum for prescribed calories, for patients with a prescription, was similar in both groups and at both times ($p > .1$) with an overall average of 1856 kcal (SD = 367, range 20–4000). There was no suggestion of any correlation between the average blood glucose and the maximum prescribed calories (Spearman rho = 0.004, $p = .89$).

Before and After Comparison

When the groups were combined, during the year of dissemination activities, we observed a significant increase in EN adequacy (from 42.9% to 50%, $p < .001$), an increase in the use of feeding protocols (from 64% to 76%, $p = .03$), and a decrease in the percentage of patients on parenteral nutrition (PN) alone or in combination with EN (from 26% to 21%, $p = .04$). We also observed trends toward improvements in percentage of patients on EN only (from 68% to 73%, $p = .07$) and percentage of patients with EN started within 48 hrs (from 52% to 58%, $p = .07$). There were no significant differences in the use of glutamine, lipids in patients receiving PN, or small bowel feeding in patients with high gastric residual volumes across data collection periods.

Clinical Outcomes

There were no significant differences in ICU length of stay, hospital length of stay, or 28-day mortality rate between the groups or across data collection periods (Table 5).

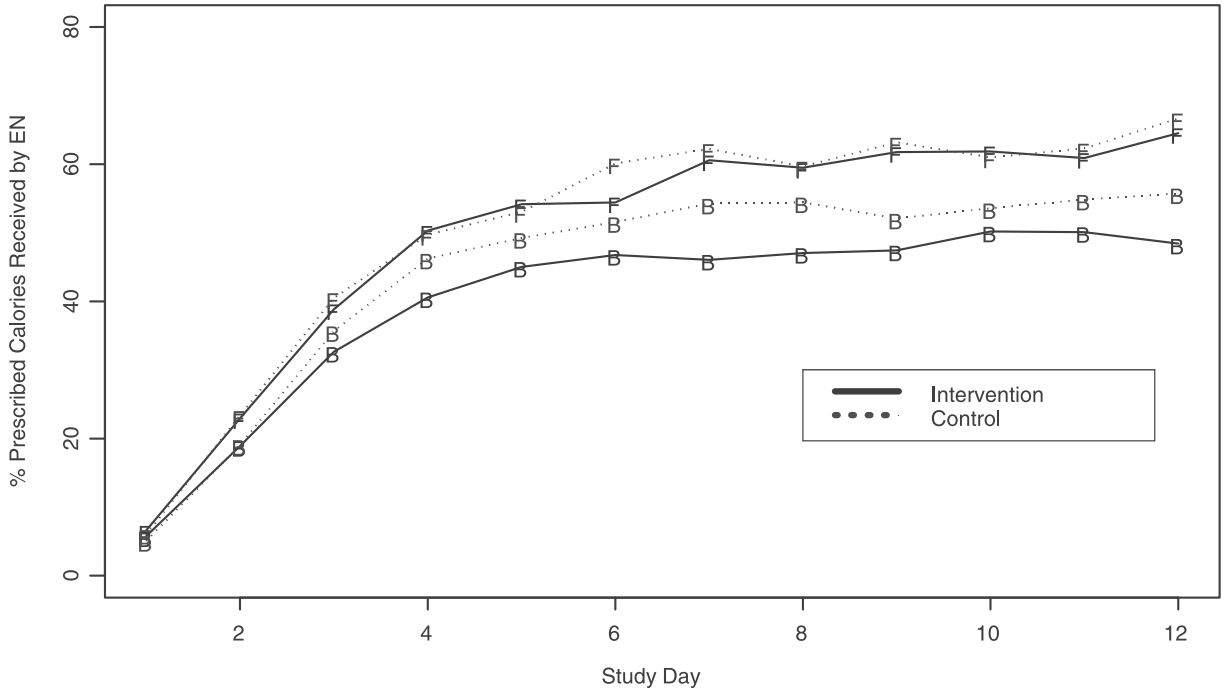

Figure 2. Adequacy of enteral nutrition (*EN*) (average daily); *B*, baseline; *F*, followup.

DISCUSSION

Clinical practice guidelines have become valued decision-making resources in medicine and have rapidly proliferated during the last decade (36). Yet the evidentiary basis for informing decisions about dissemination and implementation of clinical practice guidelines is generally weak and may not be generalizable to the critical care environment. We performed a cluster-randomized trial involving 58 ICUs across Canada to compare the effectiveness of a multifaceted, active dissemination strategy to passive dissemination alone. We were unable to demonstrate any significant differences in the change in nutritional adequacy from EN between groups. We did, however, observe significant improvements in glycemic control between groups. The decrease in the average daily glucose levels was significantly greater in the active arm as was the increase in the proportion of time with optimal glucose control and the decrease in the hyperglycemic index. Furthermore, when we compared across the time periods of the study, overall, our combined active and passive dissemination activities did translate into significant improvements in several important aspects of nutrition support practice. Patients received more EN and less PN, patients had their EN initiated earlier, and more sites were using feeding protocols. Nevertheless, there were no differences in clinically important outcomes between the two treatment groups or across time periods.

Despite the relatively minor effect of our active dissemination strategies overall, we did observe positive effects in patients with a medical diagnosis. From our previous observation studies, we observed that the practice of nutrition support in surgical critically ill patients was systematically different from that in medical patients. Surgical patients compared with medical patients were 2.9 times more likely to receive PN, waited 1.5 times longer to receive EN, and had lower EN adequacy (53% vs. 59%, $p = .014$) (7). Similar observations have been made in other ICUs in Italy (37) and the United States (8). In our study, in prespecified subgroup analyses, we saw a statistically significant increase in the adequacy of EN in the active group compared with the passive group in medical patients but not in surgical patients.

The magnitude of the treatment effect of the multifaceted dissemination strategies in our study was only modest and yet is seemingly consistent with what is reported in the literature. In a recent comprehensive review, Grimshaw et al. (15) summarized all cluster randomized trials of multifaceted intervention strategies compared with a control group that also received some form of intervention (in contrast to "no intervention") and demonstrated that the average effect size was 8.1% (range 0–24.3%).

Changing behavior and implementing guidelines in a critical care setting are undoubtedly complex tasks. Cabana et al. (38) offered a framework for considering potential barriers to guideline adoption. These barriers include a) lack of awareness and lack of familiarity affecting physician *knowledge* of the guideline; b) lack of agreement with the guidelines, lack of self-efficacy (that one can actually accomplish what is requested), lack of outcome expectancy (that if one performs the requested behavior, it will actually make a difference), and the inertia of previous practice affecting the *attitudes* of physicians toward the guideline; and c) external barriers, such as guideline characteristics, patient preferences, lack of resources, time constraints, leadership style, and organizational culture, that limit the physicians' ability to perform the *behavior* recommended by the guideline (38). We attempted to implement a multifaceted strategy to improve knowledge and awareness of our guidelines and enable and promote behavior change accordingly. However, there may be several reasons that explain why we did not observe a larger treatment effect in our study. First, the use of an intervention control group may have reduced our ability to demonstrate a difference between the two groups. The di-

Table 5. Secondary and clinical outcomes

Variable	Arm	Baseline	Follow-Up
Daily average glucose, median (IQR)[a]	Passive	8.2 (7.2–9.5)	8.1 (7.1–9.4)
	Active	8.1 (7.3–9.7)	7.7 (6.9–8.8)
Percentage of ICU stay with glucose 4.4–6.1 mmol/L, median (IQR)[b]	Passive	5.9 (0.0–19.0)	7.7 (0.7–22.6)
	Active	3.4 (0.0–14.8)	13.5 (3.6–27.9)
Hyperglycemic index above 6.1, median (IQR)[c]	Passive	2.1 (1.2–3.5)	2.0 (1.1–3.4)
	Active	2.1 (1.3–3.8)	1.7 (0.9–2.7)
Site's use of feeding protocol, n (%)	Passive	20/25 (80)	21/25 (84)
	Active	12/25 (48)	17/25 (68)
Head of bed elevation, mean ± SE	Passive	29.7 ± 1.5	29.0 ± 1.5
	Active	30.2 ± 1.5	31.7 ± 1.5
Type of nutrition support received, n (%)			
Passive	EN only	212 (71.1)	220 (72.1)
	TPN only	27 (9.1)	16 (5.3)
	EN + TPN	43 (14.4)	53 (17.4)
	None	16 (5.4)	16 (5.3)
Active	EN only	211 (64.9)	224 (73.0)
	TPN only	37 (11.4)	20 (6.5)
	EN + TPN	55 (16.9)	39 (12.7)
	None	22 (6.8)	24 (7.8)
EN initiated within 48 hrs, n (%)	Passive	156 (52.4)	183 (60.0)
	Active	168 (51.7)	171 (55.7)
Use of glutamine, n (%)	Passive	2 (0.7)	1 (0.3)
	Active	1 (0.3)	1 (0.3)
Use of motility agents in EN patients, n (%)	Passive	119/255 (46.7)	117/273 (42.9)
	Active	116/266 (43.6)	123/263 (46.8)
Small bowel feeding in patients with feeds interrupted due to high gastric residuals, n (%)	Passive	11/77 (14.3)	12/56 (21.4)
	Active	14/81 (17.3)	10/62 (16.1)
Lipid use in PN patients, n (%)	Passive	65/70 (92.9)	62/69 (89.9)
	Active	85/92 (92.4)	54/59 (91.5)
ICU LOS, days, median (IQR)	Passive	14.9 (8.3–29.9)	13.7 (7.8–28.5)
	Active	14.4 (7.3–32.3)	13.9 (8.6–33.4)
Hospital LOS,[d] days, median (IQR)[e]	Passive	27.4 (15.3–60)	28.8 (15.0–60)
	Active	28.2 (14.4–60)	29.1 (14.7–60)
28-day mortality rate, n (%)	Passive	63 (21.1)	56 (18.4)
	Active	68 (20.9)	56 (18.2)

IQR, interquartile range; ICU, intensive care unit; EN, enteral nutrition; TPN, total parenteral nutrition; PN, parenteral nutrition; LOS, length of stay. [a]Difference in change, $p = .003$; [b]difference in change, $p = .001$; [c]difference in change, $p = .003$; [d]hospital LOS is calculated as time from ICU admission to hospital discharge; [e]follow-up was censored at 60 days so true upper quartile is undefined. Binary variables are expressed as raw counts and percentages. Continuous variables are expressed as means with standard errors or as medians with interquartile ranges. There were no significant differences between groups or time periods except where noted. The total sample size is 50 clusters and 1,235 patients except where denominator noted.

etitians in the passive arm of this study were actively involved in our Canadian nutrition support network, had participated in previous national surveys, and had been made aware of the guidelines development process; some participated directly in the development of the CPGs, and all were actively solicited to participate in the cluster randomized controlled trial. This passive dissemination arm is very different from a comparison group where a guideline is simply mailed to disengaged clinicians or institutional representatives.

Second, compliance with the multifaceted interventions in the active dissemination arm was suboptimal. In the active group, audits were performed in only 36% of sites, feeding protocols were adopted or revised in only 50% of sites, and interactive workshops held in 84% of sites. Posters and manuals were used in 80% of sites, pocket cards and reminders were used in 96% of sites, and advanced organizers were only used in 52% of sites in the active arm. Changes in nutrition support practices and clinical outcomes often require significant organizational change, which can be time consuming. Organizational change and difficulties with this study were not analyzed nor were they part of our strategy. Perhaps if the time period of this study had been longer, we may have observed larger changes. In the passive group, despite no provision of tools or training, educational activities around the CPGs still occurred. The incomplete implementation of the active group and the contamination of the control group would minimize any differences between groups.

Third, the process by which we chose "opinion leaders" in this study may have been less than optimal (39). For the purposes of our study, out of convenience, we established a working relationship with clinical dietitians working in the various ICUs and attempted to position them, with all the tools and training, to lead improvement initiatives in their ICUs. However, the dietitian may not have been the most appropriate choice as an opinion leader. Other studies have shown that the use of physician opinion leaders as agents of change, identified and nominated by their local peers, has resulted in improvements to processes of care (40, 41). Working with physician opinion leaders and administrators may have enhanced the success of our efforts.

Fourth, the magnitude of our treatment effect may have been diluted because of the heterogeneity of our ICUs and patient populations. As noted, we did observe a significant treatment effect in medical patients but not surgical patients. Using a homogeneous cohort of medical patients in our

study may have resulted in larger treatment effects.

Recent evidence from another cluster-randomized trial from Canada suggests that there is an association between improved nutrition support practice and improved clinical outcomes (21). In this previous trial, sites were randomized to active dissemination of a nutritional algorithm or control (no intervention). The investigators observed an increase in the number of days on EN (6.7 vs. 5.4 of the first 10 days, $p = .04$), a decrease in the hospital length of stay (25 vs. 35, $p = .003$), and a trend toward a reduction in survival associated with the use of active dissemination strategies (27% vs. 37% $p = .058$) (21). When compared with our study, this trial had a small sample size (seven sites per arm), showed minimal changes in nutrition support practices, yet showed significant changes in clinically important outcomes. We were unable to confirm that improving nutrition support practice translates into improved clinical outcomes in our study, although our study was not adequately powered to detect such differences.

The strengths of our study include a large cluster size, an appropriate randomization of well-balanced arms, an intention-to-treat analysis, and complete follow-up. Limitations of our study include low compliance in the active group and possible contamination in the passive arm, inadequate time frame for meaningful changes to occur, and patient heterogeneity (surgical vs. medical patients).

Our study contributes to the evidentiary basis of guideline dissemination in the critical care setting and also raises some questions. Based on our results, the simplest way to disseminate and implement evidence-based guidelines in critical care is to distribute educational materials to individuals or groups responsible for quality improvement in that area in individual ICUs. As pertaining to nutrition support, further multifaceted inventions (including access to our Web-based tools, posters and pocket cards, audit and feedback, academic detailing, and interactive workshops) may be warranted, especially in patients with a medical diagnosis. The entire process uses a systematic approach to supporting guideline use by ensuring the predisposition of new knowledge, enabling local change strategies, and reinforcing ongoing improvement initiatives. However, in an era of limited financial and human resources for guideline implementation or quality improvement activities, it is not known which of the facets, or more selective combination of facets, would result in improvements in care with the least resources spent. There is no evidence that increasing the number of facets increases the effect size of the intervention (15). It would seem that bundling educational reminders (posters, pocket cards, etc.) to the educational materials would add minimal incremental costs to dissemination activities. Given that the process of developing an infrastructure to audit performance and generate site reports is costly, its efficacy, by itself, needs to be further clarified to warrant use in future guideline implementation initiatives.

CONCLUSIONS

Active dissemination of the CPGs with multifaceted strategies (including access to Internet resources, posters and pocket cards, audit and feedback, academic detailing, and interactive workshops) resulted in improved glycemic control but did not result in other significant changes in nutrition support practices or clinical outcomes compared with passive dissemination. In a subgroup of medical patients, however, active dissemination of the CPGs resulted in improved EN adequacy when compared with passive dissemination. Overall, the combined active and passive dissemination activities resulted in significant improvements in other nutrition support practices. However, these improvements were not associated with improvements in clinical outcomes. Future investigators studying implementation of CPGs may want to consider using physicians as opinion leaders.

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