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Critical Care Transition and Prevention of ICU Readmissions: A Bridge Over Troubled Waters*

James D. Chalmers, MD
Department of Respiratory Medicine
Tayside Respiratory Research Group
University of Dundee and Ninewells Hospital and Medical School
Dundee, UK

Euan Black, MD
Department of Anaesthesia and Intensive Care Medicine
Ninewells Hospital
Dundee, UK

ICU readmissions are costly, increase length of hospital stay, and are an independent risk factor for hospital mortality (1). In a large national survey from the United States, the rate of readmission within 48 hours of ICU discharge was 2%, with 4% readmitted within 120 hours (2). A similar frequency of 3.3% at 48 hours was reported in a large U.K. study (3). The IMPACT project found no reduction in readmission rates nationally between 2001 and 2007, and there is little evidence to suggest that readmission rates have fallen significantly over the past 20 years (2). Interventions to make ICU discharges safer and to support ward transition have the potential to bring great benefits to patients and significant cost savings

In this issue of *Critical Care Medicine*, Niven et al (4) have performed a systematic review and meta-analysis examining the impact of critical transition programs for patients discharged from the ICU. They identified eight before-and-after intervention studies examining the effect of a transition or support program on ICU readmissions or mortality. A total of 16,433 patients were ultimately included in the analysis.

The programs examined by Niven et al (4) were primarily nurse-led support programs and hospital outreach or medical emergency teams (5). In the pooled analysis, these interventions significantly reduced the risk of ICU readmission with an absolute risk reduction from 7.2% to 5.7% (relative risk reduction, 0.87 [0.76–0.99]; $p = 0.03$). There was a suggestion in the analysis of a reduction in mortality which did not reach statistical significance. The magnitude of effect was similar comparing the nurse-led programs with the hospital outreach teams, suggesting no clear advantage of one approach over the other (4). Limitations of the analysis must be acknowledged. All studies were nonrandomized and all but one of the studies were single center. The study could not address the cost-effectiveness of the examined interventions, and this is an important area for future research. Many of the programs incorporated dedicated members of staff and were resource intensive, requiring at least daily patient reviews until clinical stability (4, 5). Therefore, the small but significant benefits of a proposed program must be weighed against the potential resource cost.

All of the included studies were from the United Kingdom, Australasia, or Canada with none from the United States. The United States has seven times as many ICU beds per capita than the United Kingdom, and patients admitted to the ICU in the United Kingdom have very different characteristics, with a higher frequency of mechanical ventilation, a higher illness severity, and a higher ICU mortality (6). The results reported here cannot be easily extrapolated to the United States or other healthcare systems. Allowing for these reservations, this analysis supports the view that ICU transition programs can prevent a proportion of ICU readmissions.

Where are we now with step down and outreach services? In their review of critical care services more than a decade ago, the United Kingdom the Department of Health recommended the establishment of outreach services with the aim of preventing deterioration of critically ill patients on the ward, facilitating step down from ICU and educating ward-based staff (7). The guidelines on creation of outreach were not didactic, and so the makeup of services now varies widely. A national postal survey

*See also p. 179.

Key Words: meta-analysis; quality improvement; readmissions; supported discharge; transition

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in the United Kingdom published in 2007 found that although 72.8% of hospitals had a formal critical care outreach service, the services provided were heterogeneous (8). Less than 15% of hospitals provided a formal ICU transition program. There was also wide variation in the proportion of hospital wards covered, the size and composition of the team, the aims of the service, and the balance between provision of direct care and advice (8). A more defined transitional care service exists in Australia, which is usually Nurse led but other international data are lacking.

Readmission rates have been proposed as a marker of ICU quality of care. Predicting and preventing ICU readmissions requires us to first understand why they happen. A large retrospective study performed in Australia found that the strongest risk factors for ICU readmission to be chronic comorbidities, admission to a tertiary hospital ICU, and discharge between 6 PM and 6 AM (9). Discharge "out of hours" as a risk factor for readmission is a common finding in many studies and is associated with increased mortality (10). This pattern of discharge is invariably associated with pressure for beds. A study performed in a neurosciences critical care unit in United States found that days of high patient inflow volumes to the unit were associated with subsequent unplanned readmissions to the unit (11) again suggesting pressure to discharge patient's risks later readmission. Greater physiological instability at discharge is also, as expected, consistently associated with a higher risk of readmission. Using logistic regression analyses and modeling of data from patients who were discharged from ICUs, a study from the United Kingdom identified patients at risk from death on the ward with a sensitivity of 65.5% and specificity of 87.6% and an area under the receiver operating curve of 0.86. The study found mortality after discharge from intensive care may be reduced by 39% if these patients were to stay in intensive care for another 48 hours; however, this would require a 16% increase in bed capacity (12). This study was published over 10 years ago, and despite the clear need to identify patients at risk of readmission, the evidence for this sort of risk stratification is not yet strong enough to enter routine clinical practice. Whether the effectiveness of transition program interventions can be improved by targeting those patients at the highest risk of ICU admission is an important area for future research.

Transition programs have the potential to provide an important bridge through the high-risk period between ICU discharge and clinical stability on general hospital wards. Providing postdischarge support appears intuitively a positive step, but the analysis by Niven et al (4) suggests that the benefits of existing programs are relatively modest. Given the importance of preventing readmissions, future research should address the most effective (and cost-effective) ICU transition programs and the patient populations most likely to benefit.

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Critical Care Transition Programs and the Risk of Readmission or Death After Discharge From an ICU: A Systematic Review and Meta-Analysis*

Daniel J. Niven, MD, MSc, FRCPC[1,2,3]; Jaime F. Bastos, MD, PhD[1,2,4];
Henry T. Stelfox, MD, PhD, FRCPC[1,2,3,5]

Objective: To determine whether critical care transition programs reduce the risk of ICU readmission or death, when compared with standard care among adults who survived their incident ICU admission.

Data Sources: MEDLINE, EMBASE, CENTRAL, CINAHL, and two clinical trial registries were searched from inception to October 2012.

Study Selection: Studies that examined the effects of critical care transition programs on the risk of ICU readmission or death among patients discharged from ICU were selected for review. A critical care transition program included any rapid response team, medical emergency team, critical care outreach team, or ICU nurse liaison program that provided follow-up for patients discharged from ICU.

Data Extraction: Two reviewers independently extracted data on study characteristics, transition program characteristics, and outcomes (number of ICU readmissions and in-hospital deaths following discharge from ICU).

Data Synthesis: From 3,120 citations, nine before-and-after studies were included. The studies examined medical-surgical populations and described transition programs that were a component of a hospital's outreach team ($n = 6$) or nurse liaison program ($n = 3$). Meta-analysis using a fixed-effect model demonstrated a reduced risk of ICU readmission (risk ratio, 0.87 [95% CI, 0.76–0.99]; $p = 0.03$; $I^2 = 0\%$) but no significant reduction in hospital mortality (risk ratio, 0.84 [95% CI, 0.66–1.05]; $p = 0.1$; $I^2 = 16\%$) associated with a critical care transition program. The risk of ICU readmission was similar whether the transition program was included within an outreach team or a nurse liaison program and did not depend on the presence of an intensivist.

Conclusions: Critical care transition programs appear to reduce the risk of ICU readmission in patients discharged from ICU to a general hospital ward. Given methodological limitations of the included before-and-after studies, additional research should confirm these observations and explore the ideal model for these programs before recommending implementation. (*Crit Care Med* 2014; 42:179–187)

Key Words: adverse event; critical care outreach; critical illness; discharge; medical emergency team; mortality; readmission

***See also p. 216.**

[1]Department of Critical Care Medicine, University of Calgary and Alberta Health Services, Calgary, AB, Canada.

[2]Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada.

[3]Institute for Public Health, University of Calgary, Calgary, AB, Canada.

[4]Department of Critical Care, Albert Einstein Hospital, Sao Paolo, Brazil.

[5]Department of Medicine, University of Calgary and Alberta Health Services, Calgary, AB, Canada.

This work was performed at the University of Calgary.

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For information regarding this article, E-mail: tstelfox@ucalgary.ca

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Transitions of patient care between healthcare providers expose patients to potentially preventable errors and adverse events (1, 2). The transfer of patients from an ICU to a general hospital ward represents a high-risk event whereby some of the sickest patients in the hospital experience a change in healthcare providers and environment. Critical care transition programs (TPs) (i.e., programs that provide transition services for patients discharged from ICU to a regular ward) may aid in the safe transition of patients with resolving critical illness to a general hospital ward (3). The healthcare providers that administer these TPs (i.e. nurse, respiratory therapist, and/or physician) often overlap with a hospital's critical care outreach team that provides resuscitation for other acutely ill hospitalized patients (4–6). However, they are also frequently administered as part of a standalone ICU nurse-driven program (3). Therefore, the role of the TP is generally distinct from that of rapid response and medical emergency teams (METs).

Few studies have examined the effect of critical care TPs on the risk of readmission or death following discharge from a critical care unit (4–7). This includes the five systematic reviews that have examined the effects of critical care outreach/METs on hospitalized adult patients (8–12) but not on critical care TPs. As these TPs are expensive and resource intensive, it is important to understand whether they improve clinically relevant outcomes. Therefore, we performed a systematic review and meta-analysis to examine whether critical care TPs reduce the risk of ICU readmission or death, when compared with standard care among patients who survive their incident admission to an adult ICU. We defined a critical care TP as any rapid response team/system, MET, critical care outreach team/service, or ICU liaison nurse program that provided routine follow-up to patients recently discharged from ICU.

METHODS

The methods for article inclusion and data analyses were prespecified and aligned with recommendations outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and Cochrane Collaboration guidelines (13, 14). We searched for studies that examined the effect of critical care TPs on the risk of readmission or death following ICU discharge. An ICU readmission was defined as a repeat admission to ICU following discharge during the same hospitalization and included both early (< 48 hr after discharge) and late (≥ 48 hr) readmissions (15).

Search Strategy and Data Sources

The search strategy included filters for the themes critical illness, outreach programs, readmission/mortality, and controlled study designs using a combination of exploded Medical Subject Heading terms and text words that were combined with the Boolean operator "OR." The OVID interface was used to search MEDLINE (**eAppendix 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/A721), EMBASE, and the Cochrane Central Register for Controlled Trials (CENTRAL) from database inception to October 2012. CINAHL Plus was also searched via the EBSCO interface from database inception to October 2012. A language restriction was not used; however, the search was limited to human studies in adults. Additional searches were performed in two clinical trial registries (http://www.clinicaltrials.gov/ and http://www.controlled-trials.com), and abstracts from major international conferences (Society of Critical Care Medicine, American Thoracic Society, European Society of Intensive Care Medicine, and the Critical Care Canada Forum) between 2009 and 2011 were searched by hand. The authors' personal files and cited references from included studies, and bibliographies of previously published reviews, and meta-analyses were also searched (8–12, 16).

Selection Criteria

Articles were assessed for inclusion through a two-stage process. First, titles and abstracts of all studies identified by the search strategy were independently screened for their relevance to this review by two authors (D.J.N., J.F.B.). An article was considered for inclusion at this initial screen if 1) the article described original research and 2) the article appeared to describe a critical care TP. The full text of each potentially eligible study was then reviewed in duplicate to determine whether it fulfilled this study's inclusion and exclusion criteria. Studies had to meet each of the following inclusion criteria: 1) study population included adults (< 10% of study population was < 18 yr old) admitted to an ICU, 2) intervention cohort exposed to a critical care TP, 3) control population was not managed with a critical care TP, 4) ICU readmission rate reported, and 5) controlled study design (randomized clinical trial, controlled clinical trial, interrupted time series, before/after study). Articles that met any one of the following exclusion criteria were not included in the review: 1) pediatric study population, 2) no clear description of a critical care TP, 3) no control population, 4) ICU readmission rate not reported, 5) not original research, and 6) animal study. Agreement between authors was quantified using the κ statistic.

Data Extraction and Quality Assessment

Data were extracted in duplicate using a predesigned form. Extracted data described the studies, the patients, the critical care TPs, and the outcomes. Study characteristics included the study design, study year(s), the number of centers studied, the type of center (teaching vs nonteaching, closed vs open ICU), and the country(s) wherein the study was conducted. Patient characteristics included the number of patients in the intervention and control groups, case-mix, measures of illness severity, and number with a do-not-resuscitate order. Characteristics of the TPs included the structure of the team (i.e., part of a rapid response team and MET), the team members, and the frequency and length of follow-up once patients were discharged to the general ward. Outcomes of interest included the number of readmissions to ICU and in-hospital deaths (among those who survived their incident ICU admission) in the intervention and control groups. The risk of bias among the included studies was examined using the Cochrane Collaboration criteria for controlled studies (11).

Data Synthesis and Statistical Analysis

The primary meta-analysis focused on determining the effect of critical care TPs on the risk of ICU readmission. The secondary meta-analysis examined the risk of in-hospital mortality associated with a critical care TP for patients discharged from ICU to a general ward. Both of these analyses were reported as a pooled risk ratio (RR) determined through a fixed-effect model using the methods of Mantel-Haenszel (17) or a random-effects model using the methods of DerSimonian and Laird (18), as appropriate (14, 19). Interstudy heterogeneity was examined via Cochran Q test and the I-squared (I^2) statistic, wherein a p value of less than 0.05 and an I^2 value of more than 25% indicated the presence of interstudy heterogeneity (20). To examine for potential sources of heterogeneity, the primary analysis was repeated among predefined strata, namely closed versus open ICU, structure of the TP, and whether the TP included an intensivist. Visual inspection of a funnel plot and Begg test were used to assess for publication bias (21). All analyses were conducted using Stata version 12.1 (StataCorp, College Station, TX), and a p value of less than 0.05 indicated statistical significance.

RESULTS

Study Selection

The article selection process is outlined in **Figure 1**. The electronic database searches identified 3,572 citations, with an additional 18 identified through hand searches of bibliographies of included studies, other reviews, and the aforementioned list of conference proceedings. Following removal of duplicates, 3,120 articles were screened for their relevance to this study, of which 53 were selected for full-text review and nine were included in the systematic review (4–7, 22–26). Articles excluded at the full-text review stage (n = 44) commonly did not describe the use of a critical care TP (n = 34) or failed to use a controlled study design (n = 6). One study was excluded from the primary meta-analysis as it did not report the number of patients discharged to the ward following their initial ICU admission in the intervention and control groups, and the corresponding author was unable to provide the requisite data (25). Agreement between investigators at the full-text review stage was excellent as indicated by a κ of 0.8.

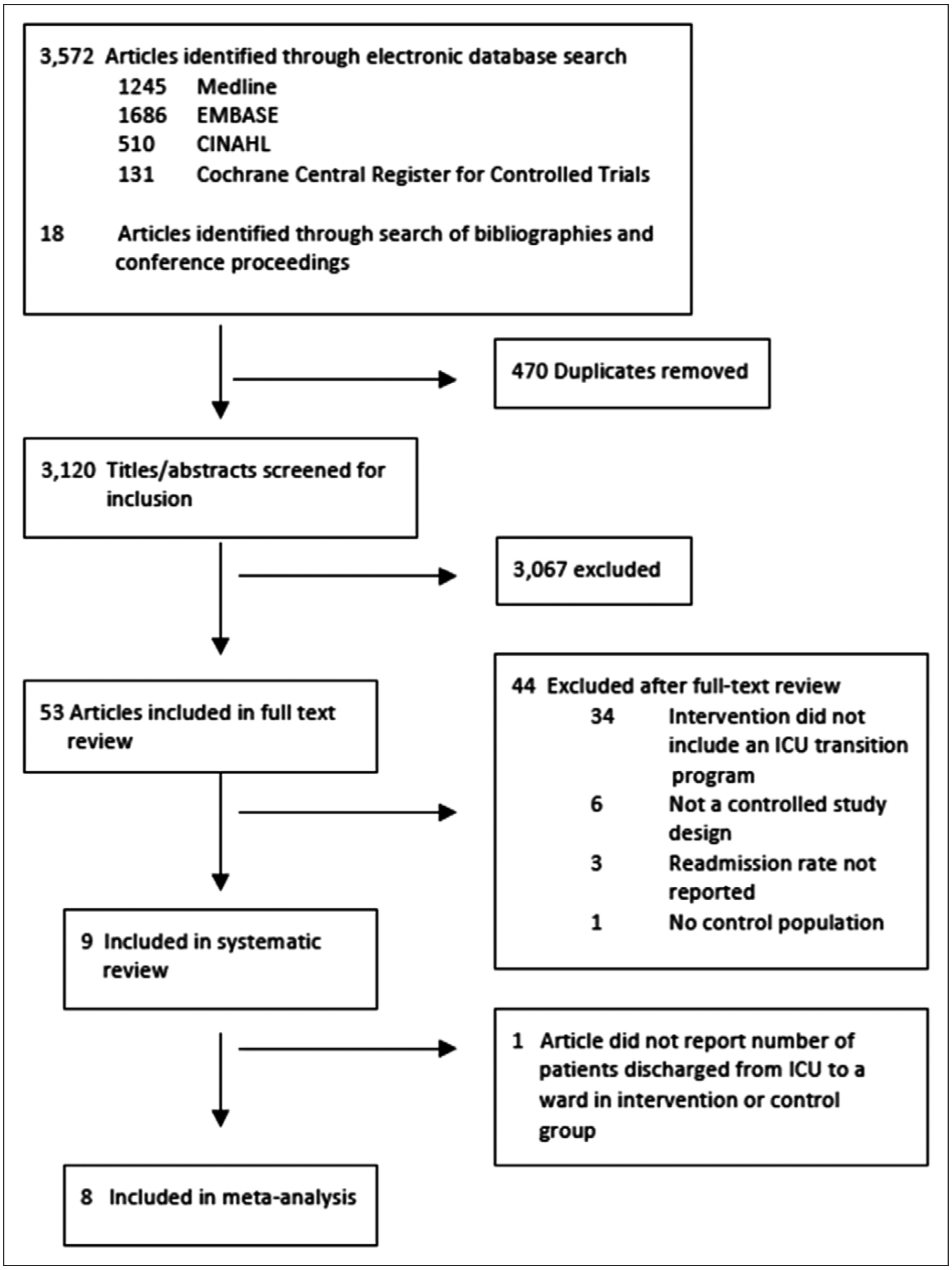

Figure 1. Details of the article selection process. The flow diagram is adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (13).

Study Description

A detailed description of the included studies is provided in **Table 1**. Each study used a before-and-after design, and all but one study (26) took place in a single hospital. Most studies occurred in the United Kingdom or Australia/New Zealand, and seven took place in teaching hospitals. Although most of these hospitals likely contained closed ICUs, only four studies clearly articulated this in their article (6, 7, 24, 26).

The total number of patients included in the primary meta-analysis was 16,433 with a median (interquartile range) of 1,516 (470–3,001) patients per study. The patients were mostly admitted to mixed medical-surgical ICUs, and among those that reported the age of the study participants (4, 5, 7, 25, 26), the mean (SD) age of the intervention and control

TABLE 1. Characteristics of the Included Studies, Their Patient Populations, and ICU Transition Programs

Study[a]	Years	Country	ICU Type	Age (Yr)	Male (%)	Illness Severity[b]	Teaching Hospital	Closed vs Open ICU
Ball et al (4)	2000–2002	United Kingdom	Medical	Intervention: 49.6 (95% CI, 47.5–51.8) Control: 51.6 (95% CI, 49.1–54.1)	Intervention: 59 Control: 59	Intervention: 16.1 (95% CI, 15.3–16.8) Control: 16.4 (95% CI, 15.5–17.3)	Yes	NR
Leary and Ridley (5)	2000–2001	United Kingdom	Medical and surgical	Intervention: 62.3 (15.8) Control: 62.0 (15.2)	Intervention: 59 Control: 60	NR	Yes	NR
Pittard (22)	2000–2001	United Kingdom	Surgical	NR	NR	NR	NR	NR
Garcea et al (23)	1999–2003	United Kingdom	Surgical	NR	NR	NR	Yes	NR
Green and Edmonds (24)	1997–2002	Australia	Medical and surgical	NR	NR	NR	Yes	Yes
Baxter et al (6)	2003–2004 vs 2006	Canada	Medical and surgical	NR	NR	NR	Yes	Yes
Eliott et al (7)	2003–2006	Australia	Medical and surgical	Intervention: 65 (18) Control: 67 (17)	NR	Intervention: 20 (9) Control: 19 (9)	Yes	Yes
Pirret (25)	2005–2007	New Zealand	Medical and surgical	Intervention: 60 (15–90) Control: NR	NR	NR	NR	NR
Williams et al (26)	2007–2008	Australia	Medical and surgical	Intervention: 54 Control: 55	Intervention: 65 Control: 65	Intervention: 16.7 Control: 16.8	Yes	Yes

TP = transition program, NR = not reported.
[a]All studies were before-and-after designs.
[b]Reported illness severity measure was an Acute Physiology and Chronic Health Evaluation II score (33).
[c]Number of discharges determined through subtracting number of ICU deaths from total number of ICU admissions.
[d]Not reported in original manuscript, but provided upon contacting the corresponding author.
Continuous data given as mean (SD or 95% CI) or median (interquartile range) if provided by the study authors.

ICU TP Implementation Date	ICU TP Name	ICU TP Composition	Follow-Up Frequency	Follow-Up Duration	Patients Discharged Alive to Ward: Intervention Period (*n*)	Patients Discharged Alive to Ward: Control Period (*n*)	ICU Readmission Definition
February 2001	Critical care outreach team	ICU nurse	At least daily	Until clinically stable	269	201	NR
February 2001	Critical care outreach team	NR	NR	48 hr	1,237[c]	1,116[c]	Readmission to the ICU or high-dependency unit prior to death or hospital discharge
Unclear	Critical care outreach team	ICU nurse and ICU physician	At least daily	Until clinically stable	214[c]	237[c]	NR
April 2001	Critical care outreach team	ICU nurse and ICU physician	At least daily	Until clinically stable	883	547	NR
1998	ICU liaison nurse	ICU nurse	Bid	Until clinically stable	4,375	652	Classified as early (< 48 hr) vs late (≥ 48 hr) or preventable vs nonpreventable
January 2005	Medical emergency team	ICU nurse, respiratory therapist, and ICU physician	NR	48 hr	675[d]	1,510[d]	Classified as early (< 48 hr) vs late (≥ 48 hr)
March 2005	ICU liaison nurse	ICU nurse	NR	Until clinically stable	807[c]	709[c]	NR
July 2006	Nurse practitioner-led critical care outreach service	ICU nurse practitioner 3 d/wk; ICU physician during off hours	NR	48 hr	NR	NR	Readmission < 72 hr
NR	Critical care nursing outreach service	ICU nurse	NR	Until clinically stable	1,435	1,566	Early (< 48 hr) vs late (≥ 48 hr)

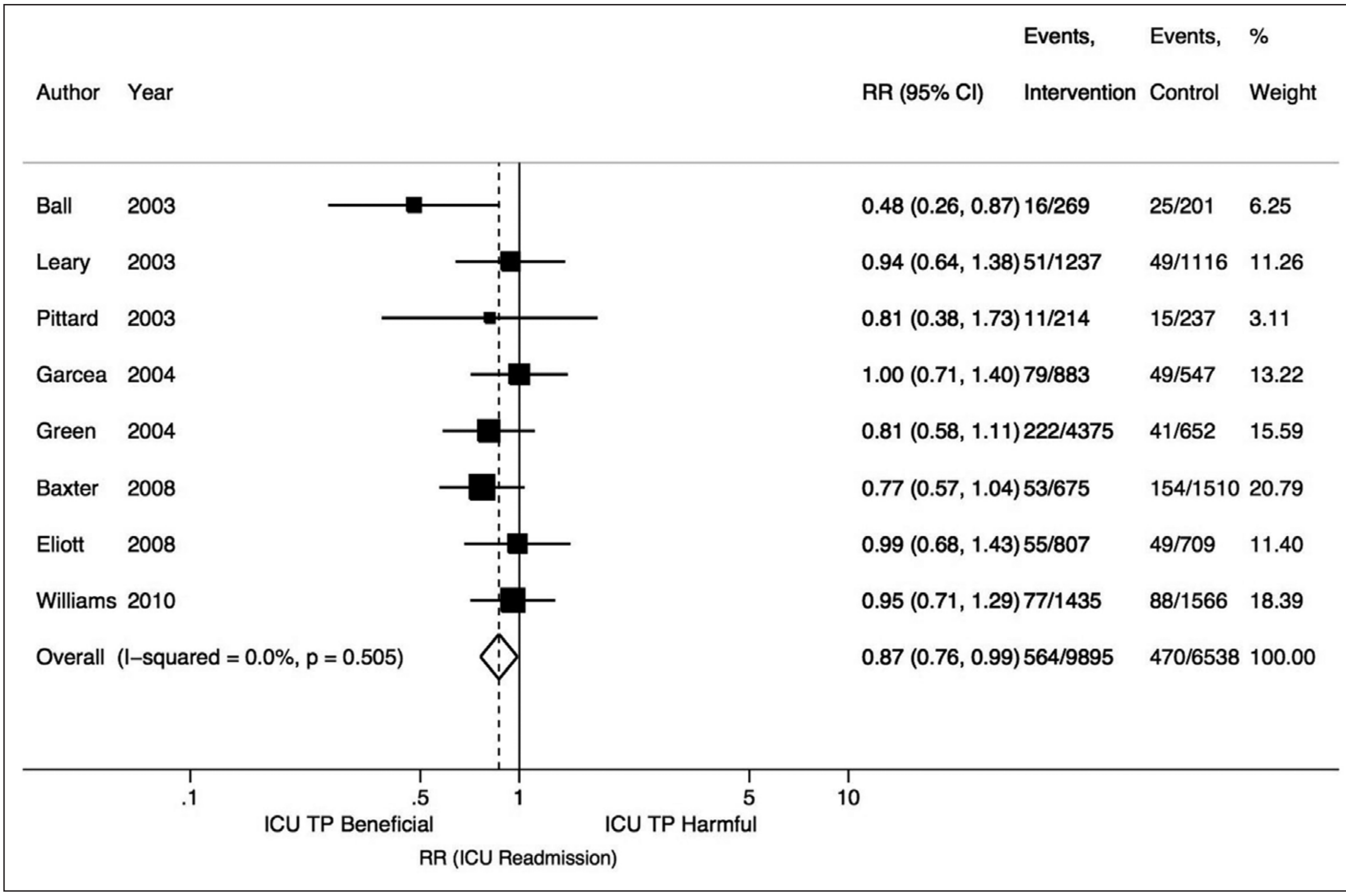

Figure 2. The effect of a critical care transition program (TP) on the risk of ICU readmission among patients discharged from ICU to the general ward. The pooled risk ratio (RR) was determined via a fixed-effect model using the methods of Mantel-Haenszel (17). *Solid squares* represent individual study estimates. *Open diamond* represents the overall pooled risk ratio. Bars and diamond width respectfully representing 95% CIs.

groups was 56 years (6 yr) and 58 years (7 yr), respectively. Similarly, the mean (SD) Acute Physiology and Chronic Health Evaluation II score was 17 (2) and 17 (2) in the intervention and control groups among studies that reported a measure of illness severity (4, 7, 26).

The critical care TPs were commonly administered by the hospital's outreach/MET ($n = 6$); however, three centers used an ICU liaison nurse to facilitate the transition from ICU to the general ward (7, 24, 26). An intensivist was an active member of the TP in only four studies (6, 22, 23, 25). Only one of the outreach/MET teams visited patients prior to ICU discharge (25), whereas the three ICU nurse liaison programs routinely visited patients prior to ICU discharge (7, 24, 26). Discharged patients were followed for up to 48 hours ($n = 3$) or until evidence of clinical stability ($n = 6$). Readmission to ICU was included in the primary outcome in six studies (4–6, 23–25).

Effect of a Critical Care TP on the Risk of ICU Readmission and Mortality

Results from the primary meta-analysis did not depend on whether a fixed-effect or random-effects model was used to pool the data. As determined by a fixed-effect model, critical care TPs were associated with a reduced risk of ICU readmission (pooled RR, 0.87 [95% CI, 0.76–0.99]; $p = 0.03$). The risk of readmission was identical when the data were pooled using a random-effects model (RR, 0.87 [95% CI, 0.76–0.99]; $p = 0.03$). This was likely due to low interstudy heterogeneity (14, 19, 27) as suggested by the Forest plot in **Figure 2** and confirmed by the I^2 statistic (0%) and Cochran Q test ($p = 0.5$). As such, the fixed-effect model was used to report the overall risk of ICU readmission associated with a critical care TP.

Although there was no evidence of interstudy heterogeneity, stratified analyses were performed to examine for differences in the risk of ICU readmission across various patient and program characteristics. As shown in the **eTable 1** (Supplemental Digital Content 1, http://links.lww.com/CCM/A721), the risk of readmission was similar whether the TP was included as a component of an outreach team (RR, 0.83 [95% CI, 0.69–0.99]) or a nurse liaison program (RR, 0.91; 95% CI, 0.75–1.10). The presence of an intensivist within the TP also did not appreciably alter the risk of ICU readmission. In addition, the risk for ICU readmission did not depend on whether or not the studies reported baseline demographic characteristics among the intervention and control groups (eTable 1, Supplemental Digital Content 1, http://links.lww.com/CCM/A721). Further analyses according to closed versus open ICUs and early (< 48 hr) versus late (≥ 48 hr) readmissions were not possible due to inconsistencies in reporting of these characteristics among the included studies. It was also not possible to determine whether the reduced risk for ICU readmission was related to

TABLE 2. Risk of Bias Among the Included Before-and-After Studies

Study	Allocation Sequence	Allocation Concealment	Baseline Outcome Similar	Baseline Data Similar	Incomplete Outcome Data	Blinding	Protection Against Contamination	Selective Reporting	Other Bias Risks[a]
Ball et al (4)	High	High	Unclear	Low	Low	High	Low	Low	High
Leary and Ridley (5)	High	High	Unclear	Low	Low	High	Low	Low	High
Pittard (22)	High	High	Unclear	High	Low	High	Low	Low	High
Garcea et al (23)	High	High	Unclear	Low	Low	High	Low	Low	High
Green and Edmonds (24)	High	High	Unclear	High	Low	High	Low	Low	High
Baxter et al (6)	High	High	Unclear	High	Low	High	Low	Low	High
Eliott et al (7)	High	High	Unclear	Low	Low	High	Low	Low	High
Pirret (25)	High	High	Unclear	High	High	High	Low	Low	High
Williams et al (26)	High	High	Unclear	Low	Low	High	Low	Low	High

[a]Each before-and-after study was at inherent risk of selection bias. No study adjusted the primary/secondary outcomes for differences in patient demographics between the two study periods; however, among studies that reported baseline characteristics, the populations appeared similar (Table 1), and stratified analyses did not detect a difference in the overall risk for ICU readmission according to whether baseline characteristics of the study populations were reported (eTable 1, Supplemental Digital Content 1, http://links.lww.com/CCM/A721).

a change in a patient's goals of care as this was infrequently reported.

We examined whether critical care TPs reduced hospital mortality among those discharged from ICU to the general ward in the three studies that provided these data (4, 6, 7). The pooled RR for hospital mortality as determined by a fixed-effect model was 0.84 (95% CI, 0.66–1.05; $p = 0.1$). Repeating this analysis using a random-effects model did not appreciably change the pooled effect estimate (RR, 0.82 [95% CI, 0.63–1.06]; $p = 0.1$).

Risk of Bias Assessment

Visual inspection of the funnel plot (**eFig. 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/A721) and Begg test ($p = 0.7$) did not demonstrate significant publication bias among the included studies. The risk of methodological bias among the included studies as assessed by the Cochrane Collaboration Criteria (11) is outlined in **Table 2**. All studies were before-and-after designs and at risk for bias. This is especially true for their susceptibility to confounding and measurement bias due to the lack of randomization and blinding. Each study was also at risk for selection bias due to a lack of allocation concealment.

DISCUSSION

This meta-analysis suggests that bridging the high-risk transition of patients from ICU to a general hospital ward through a critical care TP is associated with a reduced risk of ICU readmission. To our knowledge, this is the first meta-analysis to examine the effect of critical care TPs on the risk of readmission or death following ICU discharge. Although previous reviews of outreach/MET teams generally did not demonstrate a positive effect on important outcomes (e.g., mortality) (8–12) for hospitalized patients with sudden clinical deterioration, the current meta-analysis found that patients discharged from ICU may benefit from critical care TPs. This disparity in results is likely due to the fact that this study included different studies and focused on a more targeted intervention (critical care TPs) among higher risk patients (those discharged from ICU) than the MET studies included in previous meta-analyses (28). Consequently, this study identified a cohort of high-risk patients that may benefit from an aspect of critical care outreach (i.e., follow-up after ICU discharge) that has been widely implemented in spite of a paucity of supporting evidence. However, these results should be confirmed through additional studies that use more robust research methodology (e.g., quasi-experimental study or a prospective randomized trial) as they are based on a small number of before-and-after studies at risk for bias.

Given that critical care TPs appear to reduce the risk of readmissions among patients discharged from ICU, there is a need to further define the ideal model for these programs. Should facilitating the complex transition from ICU to a general ward be the responsibility of a hospital's multidisciplinary outreach team, or should it be included within a critical care nurse-driven program? Although the TPs included in this review were a mixture of outreach teams and nurse liaison programs, stratified analyses did not demonstrate any significant difference in the risk of ICU readmission for the nurse liaison versus outreach programs (eTable 1, Supplemental Digital Content 1, http://links.lww.com/CCM/A721). Furthermore, the presence of an intensivist did not significantly affect the risk of ICU readmission. Although these subgroup analyses may have lacked statistical power, it is also possible that the composition of the team is not as important as the mere presence of healthcare providers skilled in the early identification and treatment of recurrent critical illness. Readmission and mortality following ICU discharge are measures of hospital performance (29), and these TPs are resource intensive. Therefore, additional studies that examine the ideal model for facilitating the transition from ICU to a general ward are urgently needed.

Another important question raised by this study relates to the mechanism through which critical care TPs reduce the risk of readmissions following ICU discharge. ICUs discharge thousands of patients annually, all with disparate probabilities of being readmitted to ICU (15, 30–32). The benefit of critical care TPs may be confined to those patients at greatest risk of readmission, through increased continuity of care, identification of deviations from established care plans, and provision of timely treatment for recrudescent critical illness. On the other hand, a decrease in ICU readmissions may result from a change in the goals of care for patients discharged from ICU that develop recurrent critical illness. Given the specialized knowledge of critical care practitioners, it is not uncommon for goals of care decision making to be facilitated by members of a critical care service. Unfortunately, this meta-analysis was unable to test these hypotheses due to a lack of data regarding the risk profile for patients discharged from ICU and inconsistent reporting of the number of patients with a do-not-resuscitate order. In addition, it was not possible to assess whether TPs had different effects in teaching and nonteaching hospitals as all but one of the studies took place in a teaching institution. Therefore, future research should also attempt to identify whether there are patient and institutional characteristics that predict the greatest benefit from these programs, and how that benefit is achieved.

This study has important strengths and limitations that warrant discussion. First, to our knowledge this is the first meta-analysis to examine the effect of critical care TPs on the risk of ICU readmission and death following ICU discharge. We followed currently accepted methodological standards for the conduct and reporting of meta-analyses (13, 14) that should have minimized systematic biases within our results. The main limitations of this review relate to the risk for bias among the included studies, and inconsistencies in data reporting (e.g., baseline characteristics of the study populations) that limited the ability to assess the effect of critical care TPs on the risk of in-hospital death, and conduct meaningful stratified analyses to assess the mechanism by which ICU readmissions were reduced. In addition, the majority of TPs were based in the United Kingdom or Australia/New Zealand, thereby potentially limiting generalization of these results to other health systems. As such, these results should be considered hypothesis generating and need to be confirmed through additional studies that use stronger research methodology, such as an interrupted time series analysis or randomized clinical trial.

CONCLUSIONS

In conclusion, although critical care TPs have not been examined in a randomized clinical trial, this meta-analysis of before-and-after studies suggests that they facilitate the high-risk transition of patients from an ICU to a general hospital ward by reducing the risk of ICU readmission. However, the ideal model for such a program, as well as the mechanism through which patient outcomes are improved, should be understood through further research before recommendations regarding their implementation into clinical practice can be made.

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