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Prompting physicians to address a daily checklist for antibiotics: do we need a co-pilot in the ICU?

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Abstract

Purpose of review—Failed opportunities to reduce morbidity and mortality occur when evidence-based therapies are not fully implemented in clinical practice. We reviewed the recent literature on implementation strategies in the intensive care unit, with particular attention to antibiotic therapy.

Recent findings—Emphasis in implementation science has shifted to new models that focus more on direct, point-of-care interaction with providers as opposed to an administrative or top-down approach. Prompting physicians to use a multifaceted checklist was associated with a decrease in severity-adjusted mortality and length of stay. The majority of the benefit appears to correlate with decreased use of empirical antibiotics. A subsequent study demonstrated that face-to-face prompting regarding empirical antibiotics alone was still superior to an electronic checklist, but that long-term changes in use of empirical antibiotics resulted from the previous prompting study. Other studies demonstrate that checklists result in enhanced communication between caregivers, which may be a major explanation for their benefit.

Summary—Newer implementation strategies focused on real-time, point-of-care interventions have been associated with greater impact. The most common of these new interventions is use of checklists. Greater checklist use has led to the realization that a prompting or forcing function is required for optimal benefit.

Keywords

checklist; decision support; implementation; prompting

INTRODUCTION

Failed opportunities to reduce morbidity and mortality occur when evidence-based therapies are not fully implemented in clinical practice. A critical care example is instructive. Acute respiratory distress syndrome (ARDS) is a clinically devastating condition with more than

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Conflicts of interest

There are no conflicts of interest.

190 000 cases, 74 000 deaths, and 3.6 million hospital days annually in the USA alone [1]. Lung protective ventilation has been demonstrated in multiple studies to reduce mortality and morbidity from ARDS [2–5]. However, lung protective ventilation remains underutilized in clinical practice, and mortality outside the research setting may not be improving [1, 6–19]. This lack of adherence with lung protective ventilation has been shown to be associated with higher 2-year mortality [10].

IMPLEMENTATION STRATEGIES

Implementation interventions fall along a spectrum depending on their closeness to the point of medical decision-making (Fig. 1). On one end of the spectrum are the historical methods of implementation, such as guidelines, protocols, and public accountability. These are far removed, in space and time, from the real-time care of patients and have often been shown to be ineffective [20]. Recently, emphasis has shifted to a new model of translating knowledge into practice that focuses more on direct, point-of-care interaction with providers as opposed to an administrative or top-down approach. This model includes multifaceted, multidisciplinary interventions, such as educational outreach to local sites, audit and feedback, opinion leaders, and reminders, all of which have been shown to improve the process of care and patients' outcomes [21, 22, 23–28].

Nothing exemplifies this new paradigm more than checklists. Checklists are tools (paper or electronic) meant to be a real-time guide to clinical decision support. By acting as an 'external brain' for the user, checklists simplify and standardize care and reduce the risk of errors of omission [29]. Avoiding errors of omission is especially important in critical care medicine, given its sheer number of decisions requiring complex and sophisticated decision-making. Examples of checklist use in critical care medicine demonstrated an increased compliance with guidelines, lower rates of catheter-related bloodstream infection, and leading to earlier extubation and ICU discharge [30–35].

CHECKLIST STRATEGIES

Checklists, however, can actually fall in several places on the implementation spectrum depending on how they are introduced, and particularly whether checklist use is enforced. Recent developments in the checklist literature have attempted to clarify the specific importance of enforcement functions associated with the use of a checklist [36]. We believe that the initial enthusiasm for checklists overlooked the importance of such functions. To use the oft-cited example of checklist use in commercial aviation, airplanes cannot leave the ground until the pilot completes the preflight checklist which is monitored by a co-pilot [37]. The lack of co-pilot monitoring may be a partial explanation for the substantially higher rate of airplane crashes for private aircraft. In medicine, only a few implementation interventions can be truly said to include any co-pilot function: local opinion leaders (in select cases) and real-time reminders.

Prompting

Some form of reminder or prompt was built into successful checklists in prior research [34, 35]. In a controlled investigation, Weiss *et al.* [38] have shown that prompting critical care

physicians to use a paper daily rounding checklist improved multiple processes of care, such as less empirical antibiotic utilization, compared with the unprompted use of the same checklist. In the same study, prompting was associated with lower risk-adjusted mortality and length of stay. The importance of a real-time enforcement mechanism, such as a reminder, supports our belief that a checklist alone cannot adequately serve as an ICU co-pilot to improve process and outcomes.

In the last year, several studies have examined the role of checklist reminders, particularly as they relate to improving antibiotic utilization. Weiss *et al.* [39] conducted an exploratory analysis of their previous checklist prompting study to determine whether specific process of care improvements were a mediating factor in the lower risk-adjusted mortality that was observed. Prolonged empirical antibiotic duration was found to be associated with higher risk-adjusted mortality. More importantly, when empiric antibiotic duration was added to a multivariate mortality model, the odds of death were attenuated. The authors found that approximately 15% of the improvement in mortality which was the result of prompting physicians was explained by shorter empiric antibiotic duration. These results suggest that reducing empiric antibiotic duration through the prompted use of a checklist mediated a reduction in mortality. This conclusion counteracts the concern many providers have for discontinuing empirical antibiotics even in the face of negative culture results [40–43].

This study suffers from several important limitations. The effect of empiric antibiotic duration, a process of care parameter, on hospital mortality is difficult to interpret, as many unmeasured confounders for mortality likely existed. For example, empiric antibiotic duration may be a marker of ongoing severity of illness not captured by the Acute Physiology and Chronic Health Evaluation (APACHE) model employed in this study. Second, most of the association between prompting and mortality remained unexplained after adjustment for empirical antibiotic duration. This unexplained mediating effect is likely because of the synergistic effects that improving multiple processes of care (empirical antibiotic, mechanical ventilation, and central venous catheter duration) have on overall patient outcomes such as mortality. Another possibility is that prompting improved other processes of care or decision-making behaviors, or that a single prompt to shorten empirical antibiotics could have a snowball effect, leading to a decision to shorten empirical antibiotics for other patients seen subsequently on rounds before any further prompts were required.

Electronic prompting

Although face-to-face prompting led to several intriguing results regarding empirical antibiotic utilization, the resources needed for this intervention to clinical practice outside the research setting would be difficult to scale. Indeed, automated electronic health record (EHR)-based clinical decision support holds great promise as an ICU ‘co-pilot’. Once properly implemented, EHRs have negligible cost and resource utilization compared with face-to-face reminders. The potential for EHR-based clinical decision support for antibiotic management was recently described by Steurbaut *et al.* [44]. Their Computer-based Surveillance and Alerting of nosocomial infections, Antimicrobial Resistance and Antibiotic consumption in the ICU (COSARA) project collects and integrates a tremendous amount of

data related to patient-level antibiotic management, and delivers this information in real time to providers. Prospective validation of the value of this tool is needed.

Until recently, the automated clinical decision support possibilities of the modern EHR had not been tested directly against face-to-face reminders. Weiss *et al.* [45■] compared face-to-face prompting to reduce empirical antibiotic utilization with a checklist embedded into the EHR. The authors performed a prospective random allocation design, similar to their prior study design, in which critical care attendings and fellows on one ICU team were instructed once to complete the EHR checklist on a daily basis, whereas the other team was exposed to real-time, face-to-face prompting. The authors found that face-to-face prompting continued to improve care compared with an unprompted (in this case, EHR-based) checklist. Prompting reduced empirical antibiotic utilization compared with the EHR checklist. Also, prompting led to more than four-fold increase in deescalation or discontinuing empirical antibiotics compared with the EHR checklist.

This study contained several of the same limitations as previously described. In addition, a focus on a single-intervention technique (real-time reminders) without considering the simultaneous implementation of other techniques may have limited the potential improvement that could have been obtained. Also, the lack of a reminder system in the EHR-based checklist means that EHR-based reminders were not directly tested against face-to-face reminders. However, this study's results continue to support the hypothesis that a checklist alone is insufficient to achieve optimal process of care or patient outcome improvements. Instead, a mechanism that forces providers in real time to use the checklist as a clinical decision support tool is required to realize the greatest benefit.

Long-term benefit of prompting

The benefits of prompting might also be more lasting than previously thought. Weiss *et al.* [45■] demonstrated a conserved reduction in empirical antibiotic utilization between the unprompted EHR checklist group and the prompted group from their initial prompting study 2 years before. The authors posit that these conserved results are because of a retained culture change that occurred among the critical care physicians in this ICU as a result of their prior study. Prompting may exert its largest effect not from an individual prompt, but when a cohort of providers buys into the role a co-pilot might play in improving patient care.

Improved communication with checklists

One question about the efficacy of a checklist co-pilot is whether its use leads to improved communication among providers. Newkirk *et al.* [46■] examined this specific issue in burn and surgical ICUs. They measured baseline communication among members of the multidisciplinary ICU team based on a multifaceted daily rounding checklist, including how often a checklist parameter was not discussed. Then they implemented a new checklist and provided face-to-face prompting to address all items on the checklist if overlooked by the team. The frequency of discussing all checklist items significantly increased from baseline in both ICUs (35–77% and 47–72%, respectively). In addition, the frequency of discussing checklist items before prompting significantly increased after the new checklist and prompter were implemented. The study was limited methodologically by a

preimplementation/postimplementation design, typical of most quality improvement intervention studies, which introduces the risk of coincident interventions or other temporal confounders. However, these results support the notion that a checklist-equipped prompter can positively alter the communication patterns among ICU providers, thereby improving their practice culture.

MULTIFACETED IMPLEMENTATION WITHOUT PROMPTING

Other investigators have demonstrated improvement in critical care delivery despite not including a real-time co-pilot. One of the most comprehensive interventions reported in a study in the last year came from Sinuff *et al.* [47■], who investigated a strategy to implement guidelines for ventilator-associated pneumonia (VAP). The intervention included educational outreach, local opinion leaders, and a daily checklist (without real-time reminders). The authors found increased concordance with VAP guidelines and secondarily decreased the rates of VAP. Interestingly, this investigation combined several intervention techniques into an ongoing overall intervention plan, a strength over other studies that examined only a single-intervention technique. Although the study was limited by the premethodological/postmethodological concerns discussed above and the lack of true real-time reminders, the investigators were able to demonstrate important improvements in the implementation of evidence-based therapies and a resultant clinical outcome improvement.

CONCLUSION

Lack of implementation of interventions proven in a research setting into the clinical practice of critical care medicine continues to limit improvements in the patients' outcomes. Newer implementation strategies focused on real-time, point-of-care interventions have been associated with greater impact. The most common of these new interventions is the use of checklists. Greater checklist use has led to the realization that a prompting or forcing function is required for optimal benefit. Despite the investment required to develop this prompting function, long-term changes in clinical practice can result. Further research into implementation science is needed to develop the most effective and least expensive strategies.

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REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 516–517).

1. Rubenfeld GD, Caldwell E, Peabody E, et al. Incidence and outcomes of acute lung injury. *N Engl J Med*. 2005; 353:1685–1693. [PubMed: 16236739]
2. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. The Acute Respiratory Distress Syndrome Network. *N Engl J Med*. 2000; 342:1301–1308. [PubMed: 10793162]
3. Hickling KG, Walsh J, Henderson S, et al. Low mortality rate in adult respiratory distress syndrome using low-volume, pressure-limited ventilation with permissive hypercapnia: a prospective study. *Crit Care Med*. 1994; 22:1568–1578. [PubMed: 7924367]
4. Hickling KG, Henderson SJ, Jackson R. Low mortality associated with low volume pressure limited ventilation with permissive hypercapnia in severe adult respiratory distress syndrome. *Intensive Care Med*. 1990; 16:372–377. [PubMed: 2246418]
5. Amato MB, Barbas CS, Medeiros DM, et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. *N Engl J Med*. 1998; 338:347–354. [PubMed: 9449727]
6. Kalhan R, Mikkelsen M, Dedhiya P, et al. Underuse of lung protective ventilation: analysis of potential factors to explain physician behavior. *Crit Care Med*. 2006; 34:300–306. [PubMed: 16424706]
7. Rubenfeld GD, Cooper C, Carter G, et al. Barriers to providing lung-protective ventilation to patients with acute lung injury. *Crit Care Med*. 2004; 32:1289–1293. [PubMed: 15187508]
8. Weinert CR, Gross CR, Marinelli WA. Impact of randomized trial results on acute lung injury ventilator therapy in teaching hospitals. *Am J Respir Crit Care Med*. 2003; 167:1304–1309. [PubMed: 12574072]
9. Young MP, Manning HL, Wilson DL, et al. Ventilation of patients with acute lung injury and acute respiratory distress syndrome: has new evidence changed clinical practice? *Crit Care Med*. 2004; 32:1260–1265. [PubMed: 15187503]
10. Needham DM, Colantuoni E, Mendez-Tellez PA, et al. Lung protective mechanical ventilation and two year survival in patients with acute lung injury: prospective cohort study. *BMJ*. 2012; 344:e2124. [PubMed: 22491953]
11. Spragg RG, Bernard GR, Checkley W, et al. Beyond mortality: future clinical research in acute lung injury. *Am J Respir Crit Care Med*. 2010; 181:1121–1127. [PubMed: 20224063]
12. Checkley W, Brower R, Korpak A, et al. Effects of a clinical trial on mechanical ventilation practices in patients with acute lung injury. *Am J Respir Crit Care Med*. 2008; 177:1215–1222. [PubMed: 18356562]
13. Kallet RH, Jasmer RM, Pittet JF, et al. Clinical implementation of the ARDS network protocol is associated with reduced hospital mortality compared with historical controls. *Crit Care Med*. 2005; 33:925–929. [PubMed: 15891315]
14. Blank R, Napolitano LM. Epidemiology of ARDS and ALI. *Crit Care Clin*. 2011; 27:439–458. [PubMed: 21742210]
15. Zambon M, Vincent JL. Mortality rates for patients with acute lung injury/ARDS have decreased over time. *Chest*. 2008; 133:1120–1127. [PubMed: 18263687]
16. Phua J, Badia JR, Adhikari NK, et al. Has mortality from acute respiratory distress syndrome decreased over time?: a systematic review. *Am J Respir Crit Care Med*. 2009; 179:220–227. [PubMed: 19011152]
17. Cooke CR, Kahn JM, Caldwell E, et al. Predictors of hospital mortality in a population-based cohort of patients with acute lung injury. *Crit Care Med*. 2008; 36:1412–1420. [PubMed: 18434894]
18. Linko R, Okkonen M, Pettila V, et al. Acute respiratory failure in intensive care units. FINNALI: a prospective cohort study. *Intensive Care Med*. 2009; 35:1352–1361. [PubMed: 19526218]
19. Villar J, Blanco J, Anon JM, et al. The ALIEN study: incidence and outcome of acute respiratory distress syndrome in the era of lung protective ventilation. *Intensive Care Med*. 2011; 37:1932–1941. [PubMed: 21997128]
20. Lenfant C. Shattuck lecture – clinical research to clinical practice – lost in translation? *N Engl J Med*. 2003; 349:868–874. [PubMed: 12944573]
21. Pronovost PJ, Berenholtz SM, Needham DM. Translating evidence into practice: a model for large scale knowledge translation. *BMJ*. 2008; 337:a1714. [PubMed: 18838424]

22. Deutschman CS, Ahrens T, Cairns CB, et al. Multisociety Task Force for Critical Care Research: key issues and recommendations. *Crit Care Med.* 2012; 40:254–260. [PubMed: 22179341] The need for greater emphasis on implementation science recommended by the Task Force from critical care societies.
23. Pronovost PJ, Berenholtz SM, Goeschel CA, et al. Creating high reliability in healthcare organizations. *Health Serv Res.* 2006; 41:1599–1617. [PubMed: 16898981]
24. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA.* 1999; 282:1458–1465. [PubMed: 10535437]
25. Curtis JR, Cook DJ, Wall RJ, et al. Intensive care unit quality improvement: a 'how-to' guide for the interdisciplinary team. *Crit Care Med.* 2006; 34:211–218. [PubMed: 16374176]
26. Scales DC, Dainty K, Hales B, et al. An innovative telemedicine knowledge translation program to improve quality of care in intensive care units: protocol for a cluster randomized pragmatic trial. *Implement Sci.* 2009; 4:5. [PubMed: 19220893]
27. Scales DC, Dainty K, Hales B, et al. A multifaceted intervention for quality improvement in a network of intensive care units: a cluster randomized trial. *JAMA.* 2011; 305:363–372. [PubMed: 21248161]
28. Berwanger O, Guimaraes HP, Laranjeira LN, et al. Effect of a multifaceted intervention on use of evidence-based therapies in patients with acute coronary syndromes in Brazil: the BRIDGE-ACS Randomized Trial. *JAMA.* 2012; 307:2041–2049. [PubMed: 22665103]
29. Hales BM, Pronovost PJ. The checklist – a tool for error management and performance improvement. *J Crit Care.* 2006; 21:231–235. [PubMed: 16990087]
30. DuBose JJ, Inaba K, Shiflett A, et al. Measurable outcomes of quality improvement in the trauma intensive care unit: the impact of a daily quality rounding checklist. *J Trauma.* 2008; 64:22–27. [PubMed: 18188094]
31. Walsh TS, Dodds S, McArdle F. Evaluation of simple criteria to predict successful weaning from mechanical ventilation in intensive care patients. *Br J Anaesth.* 2004; 92:793–799. [PubMed: 15121724]
32. Byrnes MC, Schuerer DJ, Schallom ME, et al. Implementation of a mandatory checklist of protocols and objectives improves compliance with a wide range of evidence-based intensive care unit practices. *Crit Care Med.* 2009; 37:2775–2781. [PubMed: 19581803]
33. Berenholtz SM, Pronovost PJ, Lipsett PA, et al. Eliminating catheter-related bloodstream infections in the intensive care unit. *Crit Care Med.* 2004; 32:2014–2020. [PubMed: 15483409]
34. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med.* 2006; 355:2725–2732. [PubMed: 17192537]
35. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med.* 2009; 360:491–499. [PubMed: 19144931]
36. Lane D, Ferri M, Lemaire J, et al. A systematic review of evidence-informed practices for patient care rounds in the ICU. *Crit Care Med.* 2013; 41:1–15. [PubMed: 23222269] This systematic review concludes with strong recommendation for the use of structured rounding tools like checklists.
37. Gawande A. The checklist: if something so simple can transform intensive care, what else can it do? *New Yorker.* 2007:86–101. [PubMed: 18084821]
38. Weiss CH, Moazed F, McEvoy CA, et al. Prompting physicians to address a daily checklist and process of care and clinical outcomes: a single-site study. *Am J Respir Crit Care Med.* 2011; 184:680–686. [PubMed: 21616996]
39. Weiss CH, Persell SD, Wunderink RG, et al. Empiric antibiotic, mechanical ventilation, and central venous catheter duration as potential factors mediating the effect of a checklist prompting intervention on mortality: an exploratory analysis. *BMC Health Serv Res.* 2012; 12:198. [PubMed: 22794349] The benefit of prompting study most highly associated with decrease in empirical antibiotic use.
40. Aarts MA, Brun-Buisson C, Cook DJ, et al. Antibiotic management of suspected nosocomial ICU-acquired infection: does prolonged empiric therapy improve outcome? *Intensive Care Med.* 2007; 33:1369–1378. [PubMed: 17558493]

41. Namias N, Harvill S, Ball S, et al. Empiric therapy of sepsis in the surgical intensive care unit with broad-spectrum antibiotics for 72 h does not lead to the emergence of resistant bacteria. *J Trauma*. 1998; 45:887–891. [PubMed: 9820698]
42. Heyland DK, Cook DJ, Marshall J, et al. The clinical utility of invasive diagnostic techniques in the setting of ventilator-associated pneumonia. Canadian Critical Care Trials Group. *Chest*. 1999; 115:1076–1084. [PubMed: 10208211]
43. Sole Violan J, Fernandez JA, Benitez AB, et al. Impact of quantitative invasive diagnostic techniques in the management and outcome of mechanically ventilated patients with suspected pneumonia. *Crit Care Med*. 2000; 28:2737–2741. [PubMed: 10966244]
44. Steurbaut K, Colpaert K, Gadeyne B, et al. COSARA: Integrated Service Platform for Infection Surveillance and Antibiotic Management in the ICU. *J Med Syst*. 2012; 36:3765–3775. [PubMed: 22527780] An electronic tool for antibiotic management has the capability to provide real-time decision support for controlling empirical antibiotics.
45. Weiss CH, DiBardino D, Rho J, et al. A clinical trial comparing physician prompting with an unprompted automated electronic checklist to reduce empirical antibiotic utilization. *Crit Care Med*. 2013 (in press). A follow-up study to initial prompting study demonstrates greater benefit of face-to-face prompting rather than unmonitored use of electronic checklist. This study also demonstrates a persistent culture change from previous study.
46. Newkirk M, Pamplin JC, Kuwamoto R, et al. Checklists change communication about key elements of patient care. *J Trauma Acute Care Surg*. 2012; 73:S75–S82. [PubMed: 22847100] This study illustrates that one of the potential greatest benefits to checklist use is enhanced communication.
47. Sinuff T, Muscedere J, Cook DJ. Implementation of clinical practice guidelines for ventilator-associated pneumonia: a multicenter prospective study. *Crit Care Med*. 2013; 41:15–23. [PubMed: 23222254] A multifaceted implementation strategy, including unprompted checklist use, reduced the VAP rate despite variable concordance with each aspect of prevention strategy. No benefits in the length of ICU stay, duration of mechanical ventilation, or mortality were demonstrated.

KEY POINTS

- Failed opportunities to reduce morbidity and mortality occur when evidence-based therapies are not fully implemented in clinical practice.
- Implementation strategies focused on real-time, point-of care interventions, such as checklists, have been associated with greater impact.
- Greater checklist use has led to the realization that a prompting or forcing function is required for optimal benefit.
- Effective implementation, such as through checklist prompting, can result in long-term culture change.
- Enhanced communication through checklist use may be a major mechanism of implementation improvement.

Figure 1.

Spectrum of implementation interventions. Interventions can be more distant to direct patient care (e.g. public accountability) or can be directly tied to patient care in real time (e.g. reminders). Real-time reminders and some types of opinion leader interventions can be considered ICU co-piloting.