



Ventilator-associated pneumonia: Improving outcomes through guideline implementation[☆]

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Abstract Ventilator-associated pneumonia (VAP) is associated with increased duration of mechanical ventilation and increased risk of death for critically ill patients. Although scientific advances have the potential to improve the outcomes of critically ill patients who are at risk of or who have VAP, the translation of research knowledge on effective strategies to prevent, diagnose, and treat VAP is not uniformly applied in practice in the intensive care unit. Knowledge about VAP may be used more effectively at the bedside by a systematic process of knowledge translation through implementation of clinical practice guidelines. Unfortunately, there remain large gaps in our understanding of guideline implementation in the intensive care unit, specifically as it applies to guidelines for the prevention, diagnosis, and treatment of VAP.

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1. Introduction

Ventilator-associated pneumonia (VAP) continues to be a common cause of morbidity and mortality in the critically ill patient despite extensive research evidence on how to

prevent, diagnose, and treat it [1,2]. Furthermore, research knowledge on effective strategies to prevent, diagnose, and treat VAP is not uniformly applied to practice in the intensive care unit (ICU) [3]. This is supported by a recent Canada-wide survey that revealed that practices proven to prevent VAP are used inconsistently [4]. The reasons for this discrepancy are unclear, and important opportunities for improvement remain.

Currently, there are large gaps in our understanding of knowledge translation (KT) in the ICU, specifically as it applies to the prevention, diagnosis, and treatment of VAP. We postulate that VAP knowledge may be used more

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effectively at the bedside through a systematic process of KT that incorporates knowledge about clinician preferences and behavior change theory. We define a systematic process of KT as the one that uses evidence-based clinical practice guidelines (CPGs) (henceforth referred to as guidelines) and includes a guideline implementation strategy that addresses understood barriers to clinicians' adherence to guidelines, and capitalizes on the facilitators.

In an effort to bridge the gap between development and implementation of guidelines for the prevention, diagnosis, and treatment of VAP, we will discuss (1) an overview of guidelines, guideline implementation strategies, and their effectiveness outside the ICU; (2) an overview of guideline implementation in the ICU; (3) an overview of our understanding of behavior change and clinician adherence to guidelines in the ICU; (4) current knowledge about VAP guideline implementation in the ICU; and (5) a framework for implementation of a VAP guideline in the ICU. Because the data on the effect of different KT interventions are sparse, we will focus primarily on clinician behavior change and processes of care.

2. Guidelines and guideline implementation strategies outside the ICU

Significant gaps remain in the transfer of research evidence into clinical practice [5]. As many as 50% of patients do not receive care according to best evidence, and up to 25% of care is either not necessary or harmful [6]. This

has resulted in inappropriate use of drugs and technology in health care [7].

Outside the ICU, guideline implementation can improve processes of care but variably impact outcomes of care. The degree of improvement depends on the setting, target clinician and patient groups, and method of implementation [8]. Although guidelines may improve processes of care, the simple distribution of guidelines alone is insufficient to change clinician behavior [9]. Guideline implementation strategies may be passive or active. Passive strategies, such as distribution of educational materials and didactic lectures, can lead to improvements in processes of care, but may not result in sustained behavior change or improvements in clinical outcome [9]. Table 1 summarizes the effectiveness of various guideline implementation strategies; definitions are based on the Effective Practice and Organization of Care Group taxonomy [9].

In systematic reviews published before 2004 [10], regardless of the guideline implementation strategy evaluated, single-faceted active strategies (including interactive educational interventions, reminders, and prompts) were found to be more effective than passive strategies. Furthermore, multifaceted strategies (a combination of effective guideline implementation interventions such as interactive education plus reminders) adapted to address local institutional needs were the most effective. The authors proposed that both types of strategies (single faceted or multifaceted) could initiate and sustain change [10].

In a systematic review of the effectiveness of guideline implementation strategies updated in 2004, 2 key findings

Table 1 Effective Practice and Organization of Care Group taxonomy and effectiveness of guideline implementation strategies [9]

Intervention	Description	Study design (#)	Effectiveness of intervention
Educational material	Distribution of published or printed materials (CPG, audiovisual, electronic) presented in person or through mailings	RCT (9) CBA (2) ITS (7)	Modest short-lived effect on process of care Insufficient data to assess effect on patient outcome
Educational meetings	Participation of health care providers in conferences, lectures, workshops, traineeships	RCT (3)	Inconsistent effect on process of care Insufficient data to assess effect on patient outcome
Educational outreach visits ^a	Trained personnel meeting with local institution's clinicians to provide information on CPGs with intent to change behavior	RCT (14) CBA (6) ITS (1)	Modest effect on process of care Inconsistent effect on patient outcome
Reminders	Prompts for clinicians to perform a clinical action based on guideline recommendations for a specific problem	RCT (25) CCT (10) CBA (2) ITS (1)	Moderate effect on process of care No effect on patient outcome
Local opinion leaders	Use of providers nominated by their colleagues as educationally influential	RCT (8)	Inconsistent effect on clinician practice Insufficient data to assess effect on patient outcome
Audit and feedback	Summary of clinical performance over a period with or without recommendations for clinical care	RCT (8) CBA (1) ITS (1)	Modest effect on process of care Insufficient data to assess effect on patient outcome

EPOC indicates Effective Practice and Organization of Care Group; CBA, controlled before-after; ITS, interrupted time series; CCT, controlled clinical trial.

^a Only multifaceted interventions that included educational outreach reviewed.

emerged. First, multifaceted strategies had median effect sizes that were not significantly greater than single-faceted ones, and second, passive interventions such as educational materials produced moderate but significant improvements in processes of care [9]. This review seemed to contradict 2 conclusions of the earlier systematic review (eg, that significant improvement requires multifaceted strategies and that passive interventions are not useful), but it did not completely lay this issue to rest because of the heterogeneity of study designs, populations, implementation strategies, and study quality [11]. At best, single-faceted strategies of passive interventions have modest beneficial effects but do not result in sustained behavior change. An active multifaceted strategy of carefully selected interventions, which are additive in their benefit, appears to have the greatest impact. Of note, none of the studies in this review addressed VAP.

2.1. Education and reminders

Effective educational interventions must be sufficiently persuasive, informative, and relevant to the learner [12]. Implementation of single educational strategies is associated with moderate improvements in processes of care, whereas their effect on patient outcome is incompletely evaluated (Table 1). The addition of a second educational strategy such as dissemination of educational materials at meetings may result in a small, nonsignificant, incremental gain [9]. Reminders can range from low-cost verbal reminders to high-cost computerized reminders. Current evidence suggests that their effect appears moderate on processes of care, without a significant effect on patient outcome [9]. The combination of education and reminders significantly improves processes of care [9].

2.2. Opinion leaders

Opinion leaders can provide important direction and influence the clinical decisions of individuals who are uncertain about a proposed change. This occurs because these individuals can influence the beliefs, values, attitudes, and behaviors of other members. A systematic process that uses local opinion leaders may help to change clinician behavior and increase guideline adoption [13]. Clinical opinion leaders are respected sources of information, early adopters of new knowledge, and well integrated with their peers, but they are not authority figures and do not necessarily have official roles of authority [14]. They quickly adopt new knowledge to the local context and provide social support [13]. Their effectiveness may be related to their knowledge of local barriers and facilitators to behavior change.

A recent Cochrane review suggests that opinion leaders alone have mixed effects on changing clinical practice [15]. However, the addition of an opinion leader to other effective interventions may increase guideline awareness and result in more significant changes in clinician behavior (Table 1).

2.3. Computerized decision support systems

Another strategy that can improve clinically important outcomes and reduce errors in drug delivery is the use of computerized decision support systems (CDSS). A recent systematic review of CDSS found significant improvements in clinical performance, whereas fewer studies showed improvements in patient outcome. Computerized decision support systems for diagnostic tests were rarely effective, and few studies show improvements in physician performance [16]. The use of CDSS to implement a guideline for diabetes management demonstrated improvements in both the process and outcomes of patient care while overcoming barriers to guideline use [17].

2.4. Audit and feedback

A recent systematic review [9] assessed whether audit and feedback are effective in improving the performance of health care professionals and health care outcomes. The group defined audit and feedback as “any summary of clinical performance of health care over a specified period of time,” and may also include recommendations for clinical action. This review identified 81 studies of varying methodological quality. The effect of audit and feedback on improving professional practice was small to moderate. As part of a multifaceted intervention, combined with educational interventions, audit and feedback may improve processes of care of physician practice, but effects were modest. Variability in the study quality and reporting transparency makes it difficult to recommend widespread use of audit and feedback.

3. Guideline implementation in the ICU: the ICU organization and culture

Optimal strategies to implement and facilitate clinician adherence to guidelines in the ICU remain unknown. The evidence that guidelines improve care in the critically ill is limited to well-defined clinical situations, and in these, guidelines variably improve the processes [18-22], outcomes [23,24], and costs [19,24] of critical care. Studies that evaluated the implementation of guidelines in the ICU used different study designs, with modest and inconsistent effects on clinician behavior change and patient outcome.

Given the complex and dynamic ICU environment, simple implementation efforts that are effective in other clinical areas may not result in meaningful change in the ICU. Features of the ICU that pose barriers to guideline implementation and behavior change include care ministered by multidisciplinary teams, physicians with different types of formal training (anesthesia, surgery and medicine), reliance on technological support, and rapidly changing complex

critical illness. These features are different from those in the areas in which guidelines have been traditionally studied [25]. To realize behavior change in the ICU as it relates to VAP, we must know that it is important to first understand the culture of the ICU environment.

The ICU organizational climate and culture are likely determinants of guideline uptake. Organizational culture encompasses the operational norms and values of an organization; organizational climate is the perception of the culture by its health care workers. In the ICU, interprofessional care has a major influence on organizational culture and its ensuing climate because of the team model of health care delivery. Although a relationship between organizational culture and clinical outcomes has been hypothesized, few empirical studies support this relationship [26,27]; most studies focused on the value of teamwork [28]. In the ICU, knowledge about the relationship between organizational culture and outcomes is similarly limited [29].

The assumption that organizations with better organizational climates would adapt better to quality improvement initiatives, such as guideline implementation, is premature. The only supporting evidence comes from a before-after study that introduced a “culture of improvement” in one ICU that was associated with improvements in processes, outcomes, and costs of critical care [30]. The relationship between organizational culture, guideline implementation, and outcomes remains unknown and requires further study in both academic and community ICUs, because these environments differ organizationally [31].

Interprofessional relationships in the ICU may influence clinical outcomes. For example, differences in standardized mortality rates among 13 ICUs were more strongly related to interaction and coordination among the staff of each ICU than to administrative structure, amount of specialized treatment, or hospital teaching status [32]. A cross-sectional survey of 3 hospitals documented that ICU nurses’ reports of collaboration were correlated positively with patient outcomes [33]. Intensive care units with lower mortality had better developed teams and teamwork [34]. Another cross-sectional survey of 42 ICUs showed that caregiver interaction (including culture, leadership, coordination, communication, and conflict management) is related to lower risk-adjusted length of ICU stay [35].

4. Behavior change and clinician adherence to guidelines in the ICU

There are many influences on clinical decision making, including patient and clinician factors, research evidence, and health care organization [36]. Cognitive, behavioral, and administrative factors have also been shown to influence research uptake in the ICU [37]. Individual cognitive influences comprise knowledge, attitudes, and heuristics. Behavioral and administrative influences consist of current practice patterns, organizational culture, and incentives or

disincentives. Similar factors may also influence guideline uptake in the ICU. Hence, changing clinician behavior to encourage use of guidelines is an intricate process.

An understanding of what influences behavior and whether and why clinicians use evidence for acutely and critically ill patients in practice is emerging through qualitative research. In a single-center study of semirecumbency to prevent VAP in 2 ICUs [37], ICU clinicians believed that education, guidelines, reminders, audit and feedback, and quality improvement initiatives were important facilitators of placing patients in a semirecumbent position. A single-center qualitative study to understand the implementation of a hospital-wide guideline for noninvasive ventilation suggests that guidelines are multipurpose tools, serving different goals for different clinicians [38]. Important perceived barriers were lack of awareness of the guideline, unhelpful format, and apprehensiveness about change. However, most clinicians were open to change and acknowledged that guidelines can facilitate practice change.

Until recently, the role of team-based interprofessional practice and team dynamics in clinician adherence to guidelines in the ICU has not been studied. A recent multicenter qualitative study suggests that a coherent ICU team with common patient care goals and agreement with the purpose and goals of a guideline may facilitate guideline adherence [39]. Moreover, there are differences in why and how nurses and physicians use guidelines, their formatting and presentation preferences, and their view of the importance of various barriers to guideline adherence.

Single-faceted and simple implementation efforts that are effective in other clinical areas may not result in meaningful change in the ICU environment. More complex strategies, perhaps in combination, may optimize guideline adherence better than single approaches. In a prospective, single-center, observational study to increase the use of thromboprophylaxis, an implementation strategy of successive behavior change measures (including interactive, multidisciplinary educational in-services, verbal reminders to the ICU team, computerized nurse records of daily thromboprophylaxis, weekly graphic feedback to intensivists on prophylaxis adherence, and publicly displayed graphic feedback on group performance) was assessed [21]. These strategies, successively implemented, were associated with a 30% increase in the rate of thromboprophylaxis concordance from 65% up to 95%.

After developing and validating guidelines for nutritional support in the critically ill, a cluster randomized controlled trial (RCT) that compared an active to a passive strategy for their dissemination was conducted [40,41]. These guidelines were distributed by dietician opinion leaders in both groups. The active strategy group received a web-based educational intervention for guideline implementation; the passive strategy group only received copies of the guideline [42]. There was a modest but equal improvement in the adequacy of nutritional support in both groups, with no difference between groups in clinical

Table 2 Multifaceted behavior change strategies for guideline implementation in the ICU

Study design	CPG topic	Behavior change strategies	Outcomes
Jain et al [42], cRCT	Enteral nutrition	Active web-based educational strategy Dietician opinion leaders Audit-feedback	No difference on adequacy of enteral nutrition No change in patient outcome
McMullin et al [21], sequential time series	Thromboprophylaxis	Education Reminders Audit-feedback	Increase in appropriate use of thromboprophylaxis No change in patient outcomes
Baxter et al [43], pre-post	VAP	Education Audit-feedback	Reduction in incidence of VAP
Bratebo et al [44], pre-post	Sedation	Education Academic detailing Reminders Audit-feedback	Decrease in duration of mechanical ventilation
Merlani et al [45], pre-post	Arterial blood gases	Education Audit-feedback Pharmacist opinion leader Academic detailing	Decrease in number of ABGs performed Reduction in amount of blood drawn Reduction in nurses' work time Cost savings
Mascia et al [46], pre-post	Sedation	Audit-feedback	Decrease in duration of MV
Pitmana-aree et al [19], pre-post	Stress ulcer prophylaxis	Clinical pharmacist opinion leader Academic detailing Reminders	Increase in appropriate use of stress ulcer prophylaxis Decrease in medication costs No change in patient outcomes
Pilon et al [18], pre-post	Arterial blood gas	Education Reminders	Decrease in number of ABGs performed Increase in appropriate number of ABGs Cost savings No change in patient outcomes

MV indicates mechanical ventilation; ABG, arterial blood gas; cRCT, cluster randomized trial.

outcomes. Possible reasons for lack of superiority of the active strategy include the fact that the educational intervention was not piloted, evaluated, or refined; the educational intervention may not have been used optimally; the possibility that dieticians as opinion leaders may not have been the optimal behavior change agents [41]; and the fact that specific strategies to respond to low guideline concordance were not implemented. The results of this cluster RCT illustrate the challenges in conducting such research and suggest some of the factors that can impair the implementation of guidelines in the ICU.

Several other studies have also evaluated the effect of multifaceted approaches to guideline implementation in the ICU (Table 2). Although these studies suggest that a multifaceted strategy to guideline implementation may improve processes of care, most failed to show improvements in patient outcomes even when processes of care were improved. The topics, study designs, and implementation strategies were diverse, all of which may account for the differences observed. One single-center pre-post study [43] used education in combination with audit and feedback to implement a guideline for prevention of VAP, and demonstrated a reduction in the incidence of VAP. However, most studies were underpowered to detect changes in patient; important outcomes and no definitive conclusions are possible.

5. Current state of knowledge of implementation of VAP guidelines in the ICU

Without effective methods to implement guidelines at the local level, clinical practice will not change [47]. Single-center observational studies in university-affiliated ICUs [48-50] and one observational multicenter study including community ICUs [51] suggest that use of educational programs alone to implement guidelines for the prevention of VAP may be useful to reduce the incidence of VAP. There was both lack of uniformity in the way the educational strategies were implemented across studies, and educational interventions were fixed within studies. These studies tailored the educational interventions variably to physicians, nurses, and respiratory therapists. A variety of educational strategies were used, including self-study modules, multifaceted programs (didactic lectures, posters, passive provision of reference materials), and other quality improvement methods. In addition, the educational tools used were fixed; no attempt was made to modify them to meet the changing needs of the different disciplines in the groups to which they were targeted. Despite varied interventions, there was an approximately 50% decrease in VAP rates across these studies, suggesting that educational interventions should be used in the implementation of VAP guidelines. However, the lack of uniformity of the educational interventions across studies

precludes defining an optimal educational intervention or the determinants of success. The foregoing studies only focused on VAP prevention [43,48-50]; none addressed the diagnosis and treatment of VAP. They did not examine maintenance strategies and cointerventions such as reminders and opinion leaders, and most were conducted in academic ICUs.

A VAP guideline, which incorporates recommendations within the 3 domains of prevention, diagnosis, and treatment, may pose an important barrier to implementation and clinician adherence compared with a VAP guideline with a single domain, consisting of a few recommendations only. A systematic approach that incorporates several guideline implementation strategies (such as a guideline implementation team, education, a reminder system, and audit and feedback) may be required to successfully implement such a guideline.

6. Framework for implementation of VAP guidelines in the ICU

Behavior change theory can provide a framework within which we can integrate potentially effective guideline implementation strategies to help optimize implementation and clinician adherence to VAP guidelines in the ICU. Psychologic theories apply to interventions directed at individuals and teams and are categorized as motivational, action, and stages of change [52]. Advantages of the stages of change model are that they differentiate motivation and action steps and can be applied to medical education [53].

The stages of change of ICU clinicians' behavior can be represented by a combination of the precaution adoption process [54] and awareness-to-adherence [55] models of behavior change [56,57]. The combined model proposes that clinicians must first be aware of and agree with the guideline, then be motivated to change, before a guideline is adopted. The early stage when individuals are unaware of the need for behavior change may be critical to the early stages of guideline implementation [56]. Finally, guideline adherence requires a readiness to maintain that changed behavior. Failure to progress along the path from preawareness to adherence can result in failure of clinician adherence with a guideline, and may occur at any step for a variety of reasons.

Within this behavior change model, it is possible to develop a framework for guideline implementation and adherence, using guideline implementation strategies that may be effective at specific stages of behavior change. In a recent multicenter qualitative study [39], ICU clinicians reported several prerequisite conditions and strategies fundamental to the success of guideline development, implementation, and clinician adherence to guideline. An ICU that incorporates effective leadership was perceived as critical for guideline adherence. A team of ICU clinicians who facilitate implementation of the guideline may increase uptake and adherence to a guideline. In addition, regular tailored

clinician education, reminders, and an audit-feedback system were perceived as important to encourage adherence to guidelines. The use of electronic information and communication resources was labeled as extremely important to make guidelines available in a timely manner at the point of care. Hence, effective guideline implementation strategies, incorporated at specific stages of clinician behavior change, may enable guideline uptake and adherence.

A multifaceted approach to implementation of VAP guidelines in the ICU may be considered within a framework of behavior change. At the initiation of implementation of a VAP guideline, a guideline implementation team that facilitates education of the VAP guideline may increase awareness and adoption of the VAP guideline. Subsequently, ongoing continuing education with a reminder and audit-feedback system, facilitated by the guideline implementation team, may be necessary for long-term clinician adherence to the VAP guideline.

7. Summary

Health care professionals and decision makers have not marshaled a system-wide approach or system-wide resources to reduce the burden of VAP. Most initiatives use only a few of the interventions, and none have been rigorously tested [58,59]. An important barrier to the implementation of VAP knowledge is the lack of information on optimal strategies to transfer knowledge in the ICU. One approach to VAP guideline implementation is an active educational strategy combined with a reminder and audit and feedback system that is implemented by a local guideline implementation team. Such a multifaceted approach to VAP guideline implementation may help transfer VAP knowledge to the bedside and improve outcomes of care, regardless of the type of ICU. However, the optimal composition of this strategy, the necessary education efforts, the sustainability of this guideline implementation strategy, and the effect on sustained adherence to VAP guidelines have never been studied in the critical care setting. Further research is necessary to increase our understanding of effective KT strategies to improve clinical outcomes for critically ill patients who are at risk of, or who have, VAP. We are currently conducting such a study, funded by the Canadian Institutes for Health Research and in association with the Canadian Critical Care Trials Group. This KT research may also generate findings that are relevant to the implementation of other randomized trial evidence in the unique setting of the ICU.

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