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Review article

Technology-enabled performance monitoring in intensive care: An integrative literature review

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ABSTRACT

Background: Implementation of evidence-based bundles in intensive care units is integral to improving quality of care and patient outcomes. However, it increases the burden of data collection and analysis required for performance monitoring and feedback of an inter-disciplinary care team. Health information technology including electronic health records and data analytic tools could automate this process and provide real-time feedback to the team.

Aim: This integrative literature review aimed to examine the extent to which technology-enabled performance monitoring and feedback contributed to improving quality of care and patient outcomes when implementing evidence-based bundles.

Methods: A literature search of scientific databases was conducted using PubMed, Embase, Scopus, CINHAL and Ovid Medline.

Results: Of nine studies included in this review, all reported improved compliance of the team with evidence-based bundles, ranging from 3% to 60% post implementation of technology-enabled performance monitoring and feedback. Significant reductions ($p < .05$) in hospital acquired infections were also reported in five studies.

Conclusions: Overall, the addition of documentation fields to electronic health records was essential in providing real-time feedback to teams and improving their compliance with evidence-based bundles. Further research is needed to assess the effectiveness of technology-enabled performance monitoring and feedback in improving patient outcomes on a larger scale, especially in resource-limited settings such as community hospitals.

Implications for clinical practice

- Quality initiatives such as implementation of evidence based bundles require resource-intensive ongoing monitoring and feedback to improve performance.
- Electronic health records could facilitate automated data collection for audit and feedback and thus, increase efficiency and sustainability of evidence based practice.
- Overall, previous research suggests potential for improving the compliance of evidence-based bundles when seamlessly integrating documentation and performance reporting forms to the electronic health records.

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Introduction

Evidence-based practice (EBP) in intensive care units (ICU) is integral to improving quality of care and patient outcomes (Institute of Medicine, 2001). Ongoing performance monitoring and feedback (PMF) of the inter-disciplinary care team can ensure the sustainability of EBP in ICUs (Pronovost et al., 2016). However, a variety of EBP recommendations and quality initiatives implemented in ICUs increase the burden of data collection, processing and analysis required for performance audits and outcome evaluations. Electronic health records (EHRs) are considered a means to collect longitudinal health data of individuals, facilitate the efficiency of clinical workflow, and support providers' decision-making across settings. Further the adoption of analytic tools to process EHR data collected through clinical practice could promote on-going PMF process and thus, enhance the care team's compliance with recommended practice (Hayden et al., 2007). This integrative literature review, thus, was performed to better understand the impact of technology-enabled PMF mechanisms on the care team's performance and patient outcomes in ICUs.

Background and significance

In the fast-paced environment of the ICU, EBP bundles have been proven to improve patient outcomes when performed reliably as a package (Kollef, 2011; Resar et al., 2012). An EBP bundle contains a set of interventions delivered to patients by the care team (nurses, physicians, respiratory therapists) at varying intervals during the ICU stay. The Center for Disease Control and Prevention (CDC, 2010) recommends the implementation of EBP bundles in ICUs to prevent nosocomial infections, such as catheter associated urinary tract infections (CAUTI), hospital acquired pressure ulcers (HAPU), central line associated blood stream infections (CLABSI), and ventilator associated pneumonia (VAP). Compliance with EBP bundles can be tracked by computing the proportion of individual interventions completed by providers. All or none (AON) compliance is monitored by measuring the proportion of all interventions completed for an eligible patient, whereas composite compliance is observed by assigning partial credit for any intervention completed in the bundle (Nolan and Berwick, 2006).

Yet, there is a varying degree of difficulty in measuring care team compliance with EBP bundles, compounded by variations in clinical documentation (Balas et al., 2013; Collinsworth et al., 2014). Chart auditing, data abstraction and process evaluation added to the workload of providers result in an inconsistent approach to chart review and data collection (Dixon-Woods et al., 2013). Subsequently, this challenge affects process outcomes, interpretations of compliance measures (Byrne et al., 2013) and delivery of timely feedback.

Health information technology (HIT) could potentially quantify the degree to which care teams provide quality care to their patients, with consistent and efficient data retrieval from the EHR and analysis, through an automated data query and aggregation process (Hayden et al., 2007; Hermon et al., 2015). Care teams then have an opportunity to improve their performance at the bedside in real time (Brown et al., 2016). Technology-enabled feedback utilises dashboards where data from multiple sources are easily accessible to care teams via colour-coded metrics and graphs, which allows providers to focus on items that are relevant to patient outcomes (Dowding et al., 2015). Further, this type of monitoring and feedback can also facilitate process improvement across multiple sites in a health system (Chan et al., 2010; Goulet et al., 2007).

As the adoption of EBP bundles and Health Information Technology (HIT), rapidly increase in the critical care environment, it is important to understand the impact of technology-enabled monitoring/feedback on the care teams' performance and patient outcomes. This literature review, thus, aimed to examine: (1) the characteristics of EBP practice implemented in ICUs; (2) features of HIT adopted in PMF; and (3) the effectiveness of technology-enabled monitoring/feedback in improving the quality of care and/or patient outcomes.

Methods

A literature search was conducted using scientific databases including PubMed, Embase, Scopus, CINHAL and Ovid Medline. The full electronic search strategy can be found in Appendix A. According to the purpose of this review, included were original studies reporting both the adoption of a technology-enabled PMF and outcome evaluation in English between January 2005 and April 2017. It is noted that there was no research reported prior to year 2005. Of 1296 abstracts retrieved, the first author reviewed titles and abstracts for relevance and identified 46 articles for full text reviews, as shown in Fig. 1. Of these 46 articles, the first and second authors reached consensus to include nine studies according to the selection criteria above. The selected nine studies were further assessed for quality using the critical appraisal guide for quantitative studies (Fineout-Overholt et al., 2010). When assigning a point for essential elements of quantitative studies (purpose, sample size, data analysis, literature review, variables and implications for practice), all the nine studies ranged in quality from medium to high quality.

Results

Characteristics of study designs, types of EBP bundles implemented, technology features employed in PMF, and outcome measures are synthesised below. In addition, facilitators to technology adoption addressed in the literature are summarized. More detailed information on characteristics of the selected studies, research findings and relevant features of PMF systems can be found in Tables 1–3.

Characteristics of studies

All nine studies employed a quasi-experimental study design comparing study outcomes of interest before and after implementing a PMF method at large university hospitals. While three studies measured study outcomes multiple times using an interrupted time-series design (Shaw et al., 2015; Talbot et al., 2015; Zaydfudim et al., 2009), the remaining evaluated only one-time pre–and post-implementation. The number of patients included in each study ranged from 369 to 6735 due to wide variations in data collection periods in participating ICUs (three to 30-month pre-implementation, and three months to over five years post implementation) involving one to six units. Geographically, two of the nine studies were conducted outside the United States, specifically the United Kingdom and Germany (Hermon et al., 2015; Kastrup et al., 2011).

Types of EPB bundles

As shown in Table 1, five studies utilized existing EBP bundles such as CLABSI (Hermon et al., 2015; McNamara et al., 2011; Pageler et al., 2014) and VAP (Talbot et al., 2015; Zaydfudim et al., 2009). Although the CLABSI bundle includes both insertion and maintenance bundles, one of the three studies focused on only the insertion bundle (McNamara et al., 2011). The other four studies created a new bundle by putting together existing EBP recommendations. For example, Wahl et al. (2006) created a

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