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Automated Nutrition Delivery

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PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to conduct timely, rigorous, and independent systematic reviews to support VA clinicians, program leadership, and policymakers improve the health of Veterans. ESP reviews have been used to develop evidence-informed clinical policies, practice guidelines, and performance measures; to guide implementation of programs and services that improve Veterans' health and wellbeing; and to set the direction of research to close important evidence gaps. Four ESP Centers are located across the US. Centers are led by recognized experts in evidence synthesis, often with roles as practicing VA clinicians. The Coordinating Center, located in Portland, Oregon, manages program operations, ensures methodological consistency and quality of products, engages with stakeholders, and addresses urgent evidence synthesis needs.

Nominations of review topics are solicited several times each year and submitted via the ESP website. Topics are selected based on the availability of relevant evidence and the likelihood that a review on the topic would be feasible and have broad utility across the VA system. If selected, topics are refined with input from Operational Partners (below), ESP staff, and additional subject matter experts. Draft ESP reviews undergo external peer review to ensure they are methodologically sound, unbiased, and include all important evidence on the topic. Peer reviewers must disclose any relevant financial or non-financial conflicts of interest. In seeking broad expertise and perspectives during review development, conflicting viewpoints are common and often result in productive scientific discourse that improves the relevance and rigor of the review. The ESP works to balance divergent views and to manage or mitigate potential conflicts of interest.

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Operational Partners

Operational partners are system-level stakeholders who help ensure relevance of the review topic to the VA, contribute to the development of and approve final project scope and timeframe for completion, provide feedback on the draft report, and provide consultation on strategies for dissemination of the report to the field and relevant groups.

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Technical Expert Panel

To ensure robust, scientifically relevant work, the technical expert panel (TEP) guides topic refinement; provides input on key questions and eligibility criteria, advising on substantive issues or possibly overlooked areas of research; assures VA relevance; and provides feedback on work in progress. TEP members included:

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DISCLOSURES

This report was prepared by the ESP Center located at the **Durham VA Medical Center**, directed by Jennifer M. Gierisch, PhD, MPH, and Karen M. Goldstein, MD, MSPH and funded by the Department of Veterans Affairs, Veterans Health Administration, Health Systems Research.

The findings and conclusions in this document are those of the author(s) who are responsible for its contents and do not necessarily represent the views of the Department of Veterans Affairs or the United States government. Therefore, no statement in this article should be construed as an official position of the Department of Veterans Affairs. The final research questions, methodology, and/or conclusions may not necessarily represent the views of contributing operational and content experts. No investigators have affiliations or financial involvement (eg, employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties) that conflict with material presented in the report.

Executive Summary

KEY FINDINGS

- Sixteen studies were identified that assessed the impact of automated nutrition delivery innovations on health care delivery and patient outcomes. Most studies were conducted among hospitalized children and examined some form of ordering automation (alone or in combination with other automation or decision support tools).
- Most available studies reported improvements in patient, process, and performance outcomes associated with implementation of some form of automated nutrition delivery to hospitalized patients. However, available evidence for key outcomes was rated as very low certainty due to methodological limitations of the included studies.
- Findings from qualitative interviews with VHA staff involved in automated nutrition delivery innovations reviewed common implementation barriers and facilitators. Yet, overall, VHA staff expressed positive impressions of how automated nutrition innovations can improve patient care and safety and staff satisfaction.
- Findings should be interpreted with some restraint due to limitations of the identified literature. We identified a paucity of high-quality or controlled study designs, a key factor in the very low certainty of evidence rating across prioritized outcomes.

Hospital malnutrition is a common condition that often goes undiagnosed and untreated despite the role that nutrition intake plays during a hospital stay. The provision of optimal nutritional support during hospitalization is challenging due to variability in timing, dose, route of delivery (*eg,* oral, enteral, or parenteral), and type of nutrients provided. Further, many patients at nutritional risk suffer from multiple comorbidities that need to be accounted for when implementing a nutritional support plan that maximizes patient safety. To address the delivery of optimal nutritional support, many health care organizations have adopted automation technologies as promising practices to improve patient safety and satisfaction with care, nutritional support accuracy, and delivery efficiency.

Automating the delivery of nutrition for patients in the hospital setting may increase successful nutritional support while also reducing medical errors. Yet it is unknown which forms of automation are optimal and to what degree automation optimizes key clinical and patient outcomes. Also, we do not know how hospital staff implementing and delivering nutrition supports experience such automation innovations. To address these gaps in knowledge, we conducted a systematic review of quantitative and qualitative peer-reviewed literature evaluating the impact of automated nutrition delivery systems in the context of inpatient care. To supplement our findings from the literature, we conducted key informant interviews with VHA staff with experience using automated nutrition delivery supports.

CURRENT REVIEW

The VHA Nutritional Field Advisory Board requested this review to inform clinical guidance and implementation methods to optimize nutrition delivery to hospitalized Veterans. In partnership with the VHA operational partners, the following key questions (KQ) were the focus of this review:

KQ1: What are the effects of automating the delivery of oral, enteral, or parenteral nutrition supports to hospitalized patients on key process, performance, and patient outcomes?

KQ2: How is automating the delivery of oral, enteral, or parenteral nutrition supports to hospitalized patients experienced by the staff involved in implementing and delivering this innovation?

Data Sources and Searches

To identify articles relevant to the key questions, an expert medical librarian conducted a primary search of MEDLINE (via Ovid), Embase (via Elsevier), and CINAHL from inception to January 16, 2022. The databases were searched using a combination of database-specific controlled vocabulary terms and keywords searched in the titles and abstracts related to nutrition delivery.

Study Selection

In brief, the major study eligibility criteria for KQ1 were as follows: assessed the impact of automating some aspect of the delivery of nutritional supports to hospitalized patients; measured at least 1 of the prioritized process, performance, or patient-level outcomes; and used randomized or nonrandomized trials, controlled before-after studies, interrupted time series or repeated measures studies, prospective or retrospective observational studies, cross-sectional designs, or pre-post studies. For KQ2, eligible studies had to explore the experiences and attitudes of hospital staff (*eg*, nursing, pharmacy, food service, dietetics) who had interacted with some aspect of implementing and delivering the automated delivery of nutrition and use qualitative methods and designs (*eg*, focus groups, observational studies). To be included in this review, nutritional supports could have been delivered through any route: oral (by mouth), enteral (through an opening into the digestive system), or parenteral (through a vein). We defined automation of nutrition delivery as a process or application of a technology to deliver hospital-based nutrition to patients that minimizes human intervention (*ie*, "humans" provide the thinking on the ordering side [inputs], and the delivery side [outputs] is automated to minimize touch points). Relevant studies needed to include at least 1 of the following aspects of automation:

- ***Trigger of documentation*** of any step starting at nutritional assessment through termination of supplementation;
- ***Ordering*** nutrition supports; or
- ***Delivery*** of nutrition supports.

Titles, abstracts, and full-text articles were reviewed by 1 investigator and verified by another. All disagreements were resolved by consensus or discussion with a third reviewer.

Data Abstraction and Risk of Bias Assessment

Data from published reports were abstracted into a customized DistillerSR database by 1 reviewer and over-read by a second reviewer. Disagreements were resolved by consensus or by obtaining a third reviewer's opinion. Data elements included descriptors to assess applicability, quality elements, intervention details, and outcomes including adverse events.

Study risk of bias (ROB) was assessed by the revised Cochrane Risk of Bias (RoB2) for randomized trials and cluster-randomized trials, the Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) for nonrandomized studies, and NIH Cross-sectional tool Risk of Bias for cross-sectional designs. Quality assessment was completed in duplicate by 2 investigators. Disagreements were resolved by consensus between those 2 investigators or, as needed, with arbitration by a third.

Synthesis

We summarized the primary literature using relevant data abstracted from the eligible studies. Summary tables describe the key study characteristics of the primary studies: study design, patient demographics, and details of the intervention and comparator. We then determined the feasibility of completing a quantitative synthesis (*ie*, meta-analysis) to estimate summary effects. For meta-analyses, feasibility depended on the volume of relevant literature, conceptual homogeneity of the studies, and completeness of results reporting. When quantitative synthesis was not possible, we conducted a narrative synthesis focused on studies at low or moderate risk of bias.

We assessed the certainty of evidence (COE) using the approach described by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) working group. These domains were considered qualitatively, and a summary rating was assigned after discussion between 2 investigators as high, moderate, low, or very low COE.

Primary Qualitative Inquiry Methods

As we anticipated that there may be a low yield for KQ2 (qualitative evidence synthesis of hospital staff experiences), we designed and conducted a primary qualitative study to explore staff perspectives on, and experiences with, automated nutrition delivery innovations within the VHA. The Durham VA institutional review board (IRB) reviewed and designated this study as a quality improvement study. We conducted semi-structured individual interviews with VHA hospital staff involved in the implementation of some innovation to automate the delivery of nutritional supports to hospitalized Veterans. As mandated by the VHA, no potential informants were approached about this study until we had obtained approvals from VHA union representatives. The following research question was the focus of this primary qualitative inquiry: *How is automating the delivery of oral, enteral, or parenteral nutrition supports to hospitalized patients experienced by the staff involved in implementing and delivering it?*

We designed a semi-structured qualitative interview guide and analyzed data using rapid qualitative analysis. Interview transcripts and structured interviewer notes were reviewed by the qualitative team and edited for clarity. Notes were summarized into a matrix guided by the structure of the interview guide. Further analyses consisted of iterative dyad-level memo development and matrix analyses to explore common and contrasting experiences and identify themes. Disagreements were resolved via discussion and consensus.

RESULTS

Results of Literature Search

KQ1

For the KQ1 search (effectiveness of automated nutrition delivery), we identified 3,588 studies. Of these, we retained 18 studies for data abstraction, of which 16 were identified as unique studies. They consisted of 1 RCT, 1 controlled before-after study, 11 uncontrolled before-after studies, and 3 cross-sectional studies. Studies were conducted across North America and Europe (USA, Poland, Spain, and Greece). We identified no studies conducted among hospitalized VHA patients and most studies (70%) were conducted with pediatric populations.

KQ2

For the KQ2 search (experiences with automated nutrition delivery), we identified 319 articles. After applying inclusion and exclusion criteria to titles and abstracts, 42 articles were screened at the full-text review stage. Of these, none were retained for data abstraction.

Summary of Results for Key Questions

KQ1: Effectiveness of Automated Nutrition Delivery Among Hospitalized Patients

We identified 16 studies that assessed the impact of automated nutrition delivery innovations on outcomes of interest. Most studies were uncontrolled before-after studies ($N = 11$), with no studies rated as low ROB. Most studies included some form of ordering automation (*ie*, computerized provider order entry [CPOE]; $N = 12$), many of which were combined with additional features such as decision support tools. We identified only 2 studies that fully integrated nutritional products into a medication administration record (MAR) and one that used barcode scanner innovation.

- Process outcomes: Eleven studies measured process outcomes associated with the automation of delivering nutrition supports: nutrition supports delivered ($N = 5$); ordering errors ($N = 4$); and delivery errors ($N = 2$).
    - Of the 5 studies that assessed nutritional supports delivered, 2 used MAR, 1 used barcode scanner innovation, 1 used electronic medical records (EMR) alerts, 1 used CPOE plus decision support, and 1 used CPOE as a stand-alone innovation. Automating the delivery of nutrition supports resulted in increased delivery and/or earlier initiation of nutrition supplementation in 4 studies. Only the stand-alone CPOE did not report positive results.
    - The 4 studies that assessed ordering errors used these types of automation: CPOE only ($N = 2$); CPOE plus an integrated calculator ($N = 1$); and CPOE plus automation of compounding nutritional supports ($N = 1$). Of these, 3 were deemed to have sufficient homogeneity to perform meta-analysis. Pooled results indicated the implementation of CPOE significantly reduced ordering errors (OR = 0.12; 95% CI [0.06, 0.23]; 95% prediction interval [PI] [0.06, 0.24]). The additional study not included in the meta-analysis also reported substantial reductions in ordering errors associated with a CPOE plus integrated neonatal parenteral calculator (4.6 per 100 pre-implementation versus 0.1 per 100 post-implementation).
    - Of the 2 studies that assessed delivery errors, 1 used a barcode scanner and the other study used a bundled innovation of CPOE with clinical decision support and automated compounding device technologies. The barcode scanner innovation prevented 99% of delivery errors. The CPOE bundled innovation resulted in a reduction in delivery errors as well (1.6% historical control versus 0.27% with barcode scanner innovation; *p* not reported).
    - While results were highly consistent and favorable across included studies for the outcomes of nutrition supports delivered, ordering errors, and delivery errors, the overall COE was rated as very low. The COE was downgraded due to serious risk of bias, serious indirectness, and very serious imprecision.

- Performance outcomes: Only 6 studies reported on performance outcomes associated with the automation of delivering nutrition supports. These studies reported on some aspects of hospital staff satisfaction (*N* = 2) or the time savings from automation (*N* = 4).
    - Of the 2 studies that assessed staff satisfaction, 1 used MAR and 1 EMR alerts. Overall, nursing staff attitudes were significantly more favorable when comparing enteral nutrition practices after MAR implementation to pre-implementation context. The EMR alerts study only reported staff satisfaction after implementation and found 86% of survey staff endorsed "moderately high to high" utility of the innovation. While findings were consistent, the COE was downgraded to very low certainty for serious risk of bias and very serious imprecision.
    - All 4 studies that assessed some aspect of staff time saved reported a positive impact associated with implementing an automation innovation.
        - Two studies assessed staff time. One study of CPOE plus compounding automation reported significant reductions in both physician ordering time and pharmacist processing time. Another study also reported reductions in clinician ordering time for a stand-alone CPOE innovation (3.5 minutes pre-implementation versus 1.0 minutes post-implementation; *p* not reported).
        - Two studies assessed time to initiate nutrition support using MAR or CPOE plus decision support tools. Both reported reductions in the time it took to start nutritional supplementation among hospitalized patients.
- Patient-level outcomes: In total, 10 studies reported on the following patient-level outcomes associated with the automation of nutritional support delivery: time to regain birthweight (*N* = 4); calories or nutrients consumed (*N* = 5); length of hospital stay (*N* = 3); hospital readmissions (*N* = 2); and patient harms (*N* = 4).
    - Studies that evaluated time to regain birthweight included either CPOE only (*N* = 2) or CPOE plus an integrated calculator (*N* = 2) innovation. Of these, 3 observational studies were deemed to have sufficient homogeneity to perform meta-analysis. There was a significant mean difference in days to regain birthweight favoring the CPOE (MD = -2.75 days; 95% CI [-3.83, -1.67]; 95% PI [-3.83, -1.67]). The additional study was an RCT assessing CPOE plus an integrated calculator and found a positive but not significant trend in time to regain birthweight.
    - All studies that assessed some metric of supports consumed (*eg*, calories, macronutrients) evaluated CPOE, with or without additional elements: CPOE only (*N* = 3); CPOE plus an embedded calculator (*N* = 1), and CPOE with an integrated decision support tool (*N* = 1).
        - The 3 studies of CPOE only were conducted with preterm infants; all studies demonstrated a signal for increased energy intake after CPOE implementation.
    - The 2 studies that assessed CPOE plus additional components showed mixed findings. After CPOE with integrated decision support, significantly more pediatric patients achieved goal enteral nutrition within the first 48 hours after hospital admission. Yet the CPOE with integrated calculator evaluation found no difference in total calories consumed by infants compared to pre-implementation levels.

- For length of hospital stay, both CPOE innovations embedded within a MAR demonstrated a signal in reducing hospital stays, while the CPOE with decision support did not. The 2 MAR studies also assessed the impact of this innovation on 30-day hospital readmissions and found a significant reduction compared to pre-implementation rates.
- All 3 studies that assessed patient harm included CPOE with or without additional components: CPOE only (N = 1); CPOE with an integrated decision support tool (N = 1); or CPOE with decision supports and compounding automation (N = 1). All studies showed no difference in temporary or serious harms compared to pre-implementation data.

KQ2: Staff Experiences of Implementing and Delivering Automated Nutrition Delivery Among Hospitalized Patients

We identified no eligible studies that addressed KQ2.

Summary of Results for Primary Qualitative Study

While we found no published qualitative studies to address KQ2, we conducted our own qualitative inquiry into staff perspectives on, and experiences with, automated nutrition delivery innovations within the VHA. We interviewed 12 VHA employees across 4 VA Health Care Systems who had interacted with, or participated in, attempts to implement an automated nutrition delivery system. The main findings are outlined below.

- In general, VHA staff expressed positive impressions of how automated nutrition innovations can improve patient care and safety and their satisfaction as VHA hospital staff.
- Common implementation facilitators within VHA hospital were as follows: integration of an intentional planning period; use of a multidisciplinary implementation team; having a culture of innovation at their hospital; visible support of leadership (*eg*, time to participant in workgroups during regular tour of duty); effectiveness of building off existing VHA structures; and the essential role of a hospital staff member committed to implementing the practice change (*ie,* a local site champion).
- Before implementation of automated nutrition delivery innovations, perceptions of the perceived impact on workload differed across hospital staff roles (*eg*, nutrition, nursing, pharmacy, food service). Yet most VHA hospital staff informants reported minimal impacts to their work scope or workload after the implementation start-up phase.
- Staff endorsed inconsistent implementation of automation of nutrition support across VHS hospitals, though this practice is becoming the standard at many of the VHA academic partner institutions.

Discussion and Future Directions

Taken together, the results of the systematic review show a consistent trend towards positive process, performance, and patient outcomes associated with implementing some form of automated nutrition support delivery to hospitalized patients. Findings from our qualitative study provide rich complementary contextual evidence of VHA staff with experience in implementing these types of automation innovations. Moreover, our findings are consistent with other recently published studies

evaluating automated nutrition delivery innovations among hospitalized patients. Yet, our results should be contextualized due to limitations of the identified literature. Specifically, most of the included studies were uncontrolled before-and-after designs, with only 1 identified randomized trial. A majority of the studies were also rated as having considerable ROB concerns, a key factor in the overall very low COE ratings. Nearly 70% of the literature we identified centered on the use of automating nutrition support delivery among hospitalized children; it is unclear whether those findings would translate to adult hospitalized patients such as those seen in the VHA. Most of the studies used some type of CPOE, with or without additional features. We have considerably less information on the impact of MAR and barcode scanner innovations.

We are also limited in our ability to draw strong conclusions about which type of automated nutrition delivery innovation works best for what setting or hospitalized patient populations due to heterogeneity across included studies. Lastly, we found no studies that explored how hospital staff experiences automated nutrition delivery innovations; such information is vital for future implementation studies. Future studies should focus on 1) studying the impact of this promising practice within adult populations; 2) evaluating MAR innovations; 3) conducting head-to-head comparisons of different enhancements to CPOE (*eg,* CPOE + decision support versus CPOE + integrated calculator); and conducting rigorous qualitative studies of diverse staff's experiences of automating delivery of nutritional supports to hospitalized patients.

CONCLUSIONS

Food is medicine and many hospitalized patients are at risk of malnutrition during their care. Automating nutritional support delivery offers a way to standardize and document the ordering, administration, and monitoring of essential nutritional supports to hospitalized patients. Without such systems, it is difficult to know if the right nutritional products are getting to the right patient at the right time. Automating nutrition support delivery offers additional benefits, such as potential reductions in hospital staff time in ordering nutritional products. Numerous national professional societies have advocated for innovations to support the provision of nutritional products to hospitalized patients to reduce health care errors and maximize safety and quality. Our review provides evidence to support the positive impacts that automated nutrition delivery innovations may have on both hospital staff and the patients under their care. The VHA implemented BCMA software nationwide in 2000 and is thus in a unique position to advance the science on optimizing the safety, accuracy, and efficiency of inpatient nutrition delivery via automation.