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Clinical Investigation

CLINICAL INVESTIGATION

Intelligent dynamic clinical checklists improved checklist compliance in the intensive care unit

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Abstract

Background. Checklists can reduce medical errors. However, the effectiveness of checklists is hampered by lack of acceptance and compliance. Recently, a new type of checklist with dynamic properties has been created to provide more specific checklist items for each individual patient. Our purpose in this simulation-based study was to investigate a newly developed intelligent dynamic clinical checklist (DCC) for the intensive care unit (ICU) ward round.
Methods. Eligible clinicians were invited to participate as volunteers. Highest achievable scores were established for six typical ICU scenarios to determine which items must be checked. The participants compared the DCC with the local standard of care. The primary outcomes were the caregiver satisfaction score and the percentages of checked items overall and of critical items requiring a direct intervention.
Results. In total, 20 participants were included, who performed 116 scenarios. The median percentage of checked items was 100.0% with the DCC and 73.6% for the scenarios completed with local standard of care ($P<0.001$). Critical items remained unchecked in 23.1% of the scenarios performed with local standard of care and 0.0% of the scenarios where the DCC was available ($P<0.001$). The mean satisfaction score of the DCC was 4.13 out of 5.
Conclusions. This simulation study indicates that an intelligent DCC significantly increases compliance with best practice by reducing the percentage of unchecked items during ICU ward rounds, while the user satisfaction rate remains high. Real-life clinical research is required to evaluate this new type of checklist further.

Key words: checklist; decision support systems, clinical; intensive care units; medical errors; patient safety

In America, it has been estimated that the deaths of ~210 000 hospitalized patients are associated with preventable adverse events each year.[1] This large number can be explained if one considers that most medical procedures are still based on human memory.[2 3] To prevent these adverse events, a huge diversity of medical guidelines and protocols have been introduced, but it remains a challenge to implement them in daily practice. For example, only 56% of patients in the intensive care unit (ICU) are treated according to the best practice for which they are eligible.[4] To overcome these problems, a benchmark

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Editor's key points

- Checklists have been shown to reduce medical errors, but there remains some resistance to their use in practice.
- This study evaluated the simulated use of an 'intelligent' checklist incorporating real-time individual patient information in intensive care unit patients.
- Compliance during simulation with the checklist was 100%, compared with 73% using a standard paper-based checklist, which also missed several critical items.
- 'Intelligent' checklists may have potential, but real-life clinical data are required.

used in other high-risk industries, the checklist, has been tested as a method in medical care, with encouraging results.[5–10] Haynes and colleagues[5] showed that the surgical safety checklist standardizes preoperative care, resulting in a cost-effective reduction of morbidity and mortality. Likewise, De Vries and colleagues[7] demonstrated that implementing multidisciplinary checklists in the surgical pathway, from admission to discharge, significantly reduced the proportion of patients with one or more complications from 15.4 to 10.6% in Dutch hospitals.

However, numerous subsequent qualitative studies could not reproduce these beneficial effects, which could be attributable to the remaining challenge of checklist implementation in medical care, which is a lack of acceptance and compliance.[5 7 11–16] A possible cause could be that current static checklists negatively interfere with the daily workflow of caregivers because they do not provide contextual information that makes it easier to complete the checklist and they cannot include or exclude items based on the characteristics of a particular patient and caregiver.

Recently, Nan and colleagues[17] created TraceBook, a new decision support system that integrates workflow management with the use of dynamic clinical checklists (DCCs) in a process-oriented and context-aware manner to make clinical processes more traceable and the people in it more accountable. These new forms of intelligent checklists derive their dynamic property from being connected with the electronic health record (EHR) and other electronic medical databases. These checklists are therefore able to provide real-time relevant information and specific items of patients to the specific user. Our hypothesis is that these dynamic characteristics can ensure a high satisfaction rate among clinicians and improve the compliance with best eligible practice.

The aim of this study was to evaluate whether the compliance with best eligible practice is increased with this new type of checklist, while keeping the satisfaction rate high.

Methods

This simulation-based study was conducted in November 2014 in the Intensive Care Department of Catharina Hospital Eindhoven, a tertiary hospital in The Netherlands. The simulations were performed as *in situ* simulations in a real room of the ICU with a mannequin as the patient.

Scenario development

We created six patient scenarios based on data of patients who had been admitted to the ICU and deliberately implemented some flaws (Supplementary material Appendix 1). The patients were virtually admitted in the EHR-test environment (CS-EZIS test, Chipsoft BV, Amsterdam, The Netherlands).

For each scenario, we established a highest achievable score containing all the items that should be checked by the participant during each ward round. The items were identified based on guidelines, the current paper checklist (Supplementary material Appendix 2) and local expert opinion. Medical issues requiring a direct intervention were called critical items. The scenarios with their corresponding highest achievable scores were reviewed and approved by two intensivists (A.J.G.H.B. and H.H.M.K.) of the research team, who did not participate in the trial.

Study participants

Clinically active clinicians were eligible to participate if they had ward round experience on the ICU for at least 1 month between January 2013 and November 2014. Participants could be intensivists, nurse practitioners of the ICU, residents, or final year medical students after an ICU internship. Eligible participants were invited to participate, and participation was voluntary. When completing the survey, participants gave verbal and written consent for the use of the collected data for publication.

Local standard of care

The current local standard of care (LSC) during an ICU ward round is a paper checklist that is available at the bedside to be used at the caregiver's convenience. This paper checklist is based on the FAST HUG mnemonic,[3 18] and since its introduction on the ICU, intensivists have optimized this checklist by adding extra items (Supplementary material Appendix 2).

For more than a decade, the Catharina Hospital Eindhoven has also been using the clinical decision support system (CDSS) GASTON to improve guideline compliance regarding medication.[19–21] This CDSS is connected to the EHR and checks predetermined pharmacological clinical rules for the ICU (Supplementary material Appendix 3). If these clinical rules are violated, the CDSS produces alerts.[20] An example of such a violation could be a patient on the ICU receiving non-steroidal anti-inflammatory drugs without gastric protection. Once a day, after the ICU ward rounds, a list of all the alerts is generated and evaluated by a hospital pharmacist, who then contacts the physician on duty by telephone to discuss the recommendations. This physician decides whether a recommendation should lead to an intervention or not.[20]

Intelligent dynamic clinical checklist

The intervention was based on the use of an intelligent DCC that generates a dedicated checklist for each individual patient. To do this, the systems of TraceBook and GASTON both use a rule engine containing a model of algorithms, comparable with a decision tree, with general clinical rules and pharmacological rules that are both specifically applicable to the ICU.[19 20] First GASTON gathers the relevant information about the patient from different medical information systems, such as patient monitors, the EHR, the pharmaceutical prescription system, and others. Then GASTON and TraceBook run the rule engines containing the clinical and pharmaceutical rules with their algorithms, and TraceBook determines which rules are relevant for a specific patient in a specific context and should become a checkable item for the DCC of that particular patient. Some of these items can be checked automatically, depending on the available information, on the algorithm of the rules, and on whether local consensus of the professionals decided that a rule