Voice Controlled Transcription/Automation of Medical Checklists

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Selected Papers and Relevance to Project

The use of electronic checklists in the medical field, as well as the use of a tool to create a customizable electronic checklist, is a fairly unexplored area. As a result, my review of current checklists is based on a review of paper checklists and those used in the aviation field. Unfortunately, the development of checklists and study of their effectiveness is very new to the field, and as a consequence, most of the information available is qualitative rather than quantitative.

- Heitmiller, G. Checklists in Healthcare. Society for Pediatric Anesthesia. Oct. 2009

  This paper discusses significance of using checklists in the medical field. It is filled with examples of both successful and unsuccessful checklists that have been implemented. This gives a good history of medical checklists and their significance, to date.

- Hales, B., *et al*. Development of medical checklists for improved quality of patient care. International Journal for Quality in Health Care 2008; 20(1):22–30

  This paper discusses a review of literature to outline the methodology of designing and implementing clear and effective medical checklists. It is important that our customizable checklist allows the user to create easy to use, effective checklists.

- Boorman, D. Today's electronic checklists reduce likelihood of crew errors and help prevent mishaps. ICAO J 2001; 1:17-36

  This article discusses use of electronic checklists in the aviation field. Most of the medical field's checklists are modeled after those used by aircraft carriers. Electronic checklists are no exception, and therefore, with a lack of (electronic checklist) examples in the medical field, we must look to aviation for guidance.

Background

Since the Institute of Medicine's report, "To Err is Human," published in 1999, suggested that there were 100,000 deaths annually from medical error, the medical field has been searching for ways to improve this statistic. One such way is a simple checklist. A simple checklist can standardize what, when, how, and by whom interventions are done and can reduce errors in routine and emergency situations.

Checklists provide a public framework to ensure adherence to clinical or procedural requirements. This shared knowledge of checklist content also allows caregivers to mutually support each other by cross-checking what is being done and in what order. These assurances are important, especially when time is short, the pressure is on, or when competing priorities distract our attention.

Heitmiller Gives Many Examples of both Successful and Unsuccessful Checklists

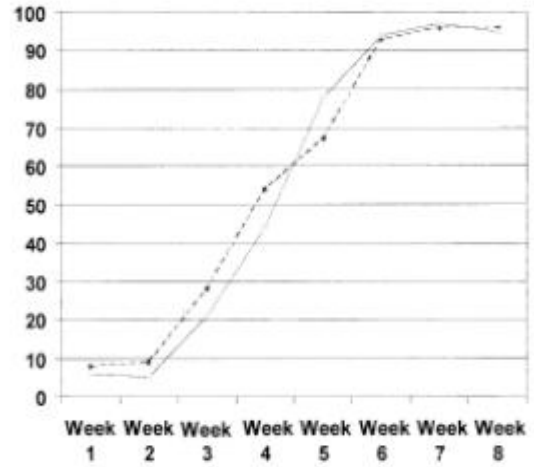
In Heitmiller's paper, he reviewed many examples of checklists in practice. One such successful checklist was a daily goal checklist, implemented at the Johns Hopkins Hospital's surgical intensive care unit (ICU). Here, a study was done using a simple checklist as a tool for the healthcare team to better understand the daily goals of patient care. This daily goal checklist increased the nurses' and housestaff's understanding of the patient care plan from 10% to 95% over eight weeks and reduced the length of stay by 50%, from 2.2 days to 1.1 days. Both the checklist used in this study and the statistics are shown below.

Figure 1. Daily Goals Checklist[2]

- ☐ What needs to be done for the patient to be discharged from the ICU?
- ☐ What is this patient's greatest safety risk? How can we reduce that risk?
- ☐ Pain management and sedation
- ☐ Cardiac - volume status
- ☐ Pulmonary - ventilator (plateau pressure, elevate head of bed)
- ☐ Mobilization
- ☐ Infectious disease - cultures, antibiotic levels
- ☐ Nutrition
- ☐ Medications - can any be discontinued?
- ☐ Tests and procedures
- ☐ Review scheduled labs and x-rays
- ☐ Consultations
- ☐ Communication with primary service
- ☐ Family communication
- ☐ Can any catheters or tubes be removed?
- ☐ Is this patient receiving DVT or peptic ulcer prophylaxis?

ICU, intensive care unit; DVT, deep venous thrombosis

Percent of residents (dotted line) and nurses (solid line) per week understanding patient care goals.[2]



Summary of Work: Review of Checklist Use

These three articles review methods for creating effective checklists and their impact on users. Each has a unique perspective and will be discussed below.

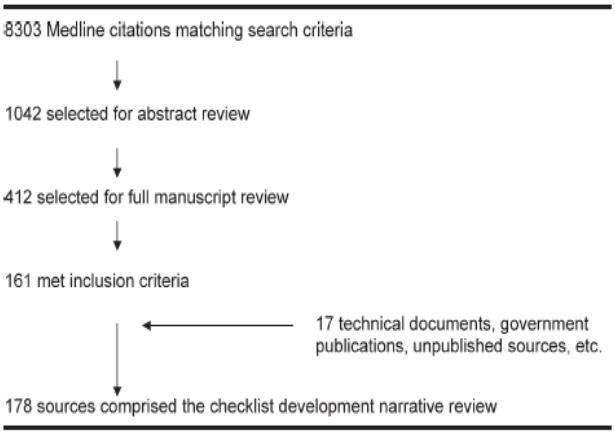
Heitmiller focused on the review of published examples of the effective use of checklists in medicine. In addition to the Johns Hopkins Hospital's ICU (described above), he found that the Harford Hospital's ICU and another, separate (unstated location's) pediatric ICU both benefitted from the use of a simple daily goals checklist.

Other types of checklists in which successful examples were given include a catheter-related bloodstream infection (CRBSI) care team checklist. In this study, a 16-bed surgical ICU (with a 15-bed cardiac control ICU) found that the CRBSI rate dropped from 11.3 per 1,000 catheter days to zero in the final quarter of the study. In addition, authors of the study estimated that the intervention prevented 8 deaths, 43 CRBSI, and nearly $2 million in additional costs per year.

Some examples of ineffective checklists include a pre-anesthesia checkout checklist that has been in place for over 20 years as well as the Food and Drug Administration checklist. Unfortunately, it is not clear from the paper as to what has caused their ineffectiveness.

Hales review on medical checklists included a MEDLINE search for "checklist" literature and focused on designing effective checklists. These results were supplemented by expert opinion in the area of checklist development and implementation. A detailed breakdown of how they obtained their sources is given in the chart to the right.

Table I Literature search



Boorman discusses in his article the advantages and disadvantages of electronic checklists (ECL) over paper checklists. This review is based on the use of checklists in the field of aviation, an area that medical checklists are commonly modeled after.

Key Results (Heitmiller's results are discussed above in background)

Hales: Development of Medical Checklists for Improved Quality of Patient Care

Hales identified five basic types of checklists commonly used to facilitate identification of errors of omission. For our project, we will be able to implement the laundry list, the sequential checklist, the iterative checklist and the criteria of merit checklist. Our reasoning for not including the diagnostic checklist is simply that in a customizable format, there is no easy way to implement when to follow specific steps and when not to. A simple mistake in this type of checklist could omit (or add) a potentially harmful step to the checklist where it does not belong. If we complete all of our expected and maximum deliverables, then we can look more into this type.

Table 2 Types of checklists [22]

Type of checklist	Description	Example
Laundry list	Items, tasks or criteria are grouped into related categories with no particular order	Medical equipment checklist Grocery list
Sequential or weakly sequential checklist	The grouping, order and overall flow of the items, tasks or criteria are relevant in order to obtain a valid outcome	Procedure checklist (equipment must be gathered before procedure can begin)
Iterative checklist	Items, tasks or criteria on the checklist require repeated passes or review in order to obtain valid results, as early checkpoints may be altered by results entered in later checkpoints	Continued re-checking of the pulse and blood pressure in algorithms or checklists for adult cardiopulmonary resuscitation
Diagnostic checklist	Items, tasks or criteria on the checklist are formatted based on a 'flowchart' model with the ultimate goal of drawing broad conclusions	Clinical algorithms
Criteria of merit checklist (COM list)	Commonly used for evaluative purposes, in which the order, categorization and flow of information is paramount for the objectivity and reliability of the conclusions drawn	Checklist for diagnosis of brain death Objective structured clinical examination checklist

When developing medical checklists, Hales identified many specific considerations that are necessary for successful formatting of the checklist, as shown on the following page. Of these, the context, the last bullet in content, the structure, the images, and the last bullet in usability are most relevant to our project, as they have to do more with developing a template for checklists or where checklists fit into the overall picture, rather than how to actually write a specific checklist for a specific surgical procedure.

Although Hales identified both types of checklists and formatting, the main purpose of the article was actually to develop a systemic approach to design and develop checklists. Their result is also shown on the following page.

In their research, Hales also noted that there is no published data to date indicating that checklists may contribute to adverse events, such as imposing a burden on the primary care providers, causing delays in treatment because of lengthy checklists, or errors of omission.

Table 3 Considerations for formatting a medical checklist

Criteria	Consideration
Context	• Location of the checklist should be determined prior to development. If it is to be stored in a medical record upon completion, the checklist it will need to be processed through the appropriate hospital regulatory bodies.
Content	• When possible, synthesis of published peer-reviewed guidelines and evidence-based best practices should be considered to form the body of the checklist. • Literature employed for generation of criteria points should be from a broad range of peer-reviewed, reliable sources and include perspectives of all types/disciplines that represent the continuum of intended users [36]. This is particularly important if the medical checklist is to be used by all personnel within a multidisciplinary team of healthcare providers. • Checklists should also reflect the local hospital and institution policies and procedures.
Structure	• Checkpoints should be presented in a logical and functional order that reflect the sequence or flow of real-time clinician activities and regular patient care routines. • If the checklist is to be part of standard patient care, it might be important to include a checkpoint at the end where two users can sign off that it was completed. • e.g. space for nurses to confirm that the checklist was completed by the physician.
Images	• Clear, equally spaced, bold fonts are suggested for letter differentiation and reading comprehension [37]. • If colours are to be used—ensure that they are consistent with those commonly used in the intended environment. • e.g. if red is commonly associated with emergency situations, it should not be used to highlight text unless it is urgent information. • Checklists should include appropriate institutional logos or letterheads if necessary (e.g. if it is to be included in the medical record, it will have to match the format of other forms/orders).
Usability	• Checklist should not be so onerous or time consuming as to notably interfere with administration of patient care. • Overall checklist should encompass checkpoints of major importance, while still providing clinicians with the freedom to use their own judgment. • Members of each discipline within a unit should pilot the checklist, particularly if the checklist is to be used by all personnel within a multidisciplinary team of health care providers. • Validation of the checklist should occur, where possible, within the appropriate simulated clinical environment.

- Determine need for the checklist
- Identify the goal and audience for the checklist
- Develop content using the following:
  - Broad spectrum of peer-reviewed literature
  - Expert judgment
  - Consensus among relevant opinion leaders
  - Multidisciplinary input
  - Consideration of current practices
- Design must consider (see Table 4) [26, 30]:
  - Context for the checklist
  - Readability
  - Proper categorization of information
  - Structure of checkpoints
  - Limited use of images
  - Appropriate use of colour
  - Avoid jargon —use common terminology
  - Flow of real-time user activities
  - Clinician state of mind
- Pilot test — validation in simulated clinical environment is a must
- Review with appropriate multidisciplinary representation
- Obtain approval from appropriate regulatory authorities as required, prior to implementation in the clinical environment
- Develop an education plan to properly train users
- Frequent review of evidence-based checklist content

Boorman: Today's ECL's reduce likelihood of crew errors and help prevent mishaps

In this article, Boorman discusses many advantages and disadvantages of using electronic checklists over their paper counterparts. Some of these advantages include the prevention of the skipping of an important step in the checklist, the ability to check entered values for errors, and the ability to create a consistent, predictable human-computer interface (HCI). He also states that an unpublished Boeing simulator study of ECL performance found a 46% decrease in errors as compared to paper checklists. A table detailing many advantages of ECLs is shown below.

Figure 1. Paper checklist error modes and corrective features contained in the B777 ECL

PAPER CHECKLIST ERROR MODE	777 ECL FEATURE
Both Normal and Non-normal Checklists	
One or more items are skipped in checklist	Current line item box jumps to incomplete item. "CHECKLIST COMPLETE" indication will not display until all items complete
Place is lost in checklist when crew distracted by higher priority task or checklist	Automatic place holding when returning to an incomplete checklist
Incorrect switch is selected	Sensed line items will not turn green
Excessive psychomotor workload due to holding, turning/marking pages, recovering dropped or misplaced paper checklist	Panel mounted display and one-hand cursor controller (this includes a disadvantage: lack of portability; pilot cannot move checklist along with visual scan)
Checklist is misread or unreadable due to poor illumination	Display readable in any lighting condition
Normal Checklists (NC) Only	
NC is skipped	Next normal checklist in sequence always displayed
NC is not initiated	Not prevented. Checklist is displayed later when ECL next accessed, providing error feedback
Non-Normal Checklists (NNC) Only	
Incorrect NNC is accomplished for the annunciated condition	Correct NNC automatically placed in queue when airplane system fault message displayed
NNC is skipped or left incomplete	Checklist queue lists incomplete or unaccessed checklists. Amber "NON-NORMAL" indication displayed
Incorrect steps are accomplished in a branching checklist	Current line item box moves to next step in correct branch. Incorrect branch displayed in cyan (cyan indicates inapplicable items)
Steps to be accomplished later in flight are not accomplished	Deferred line items automatically attached to Approach or Landing checklist
Operational notes or revised limitations following a malfunction are forgotten	Notes automatically collected for review at any time; must be reviewed to complete Approach checklist
Wrong steps accomplished when multiple related failures have conflicting or redundant actions	Correct steps are collected in single checklist. Consequential checklists inhibited
Excessive cognitive workload in multiple failure case leads to omitted NNC or other errors	ECL cognitive workload and accomplishment times lower than paper

Although these advantages increase the desire to develop electronic checklists over paper ones, there are a few points that must be kept in mind in order to make them more successful. First, the use of electronic checklists could create training challenges if the checklists are much more complicated than a simple paper checklist. Second, by creating and running the checklist electronically, it is possible to introduce new errors that are not possible with simple paper checklists. In addition, early prototype testing of the ECL revealed that many pilots react to an electronically displayed instruction in a more compulsory manner and treat it less critically than instructions printed on paper. Under most circumstances, this can be viewed as a very negative

effect, as the user should always thoroughly address any issues and treat each step as a critical step, especially in surgical procedures.

Significance of Findings to Our Project

To make our program more robust, we must allow for diversity in the types of checklists we allow users to create. Also, as the appearance of information and the use of visual elements can directly influence the overall efficacy of the document, we must ensure that the customizable checklist will be structured in such a way to allow for easy navigation and completion. There are guidelines on effectiveness, including selecting appropriate graphics, balancing the number and placement of visual elements, appropriate use of colors, and shading and textual elements.

We must thoroughly test our program after completion to ensure that we are not introducing any new errors. This would contradict the entire purpose of the project- to reduce errors in surgical procedures and increase patient safety.

We need to incorporate the advantages of aviation electronic checklists into our program, including a standardized format, clearly showing where in the checklist the user is, and checking to make sure all required steps are completed before moving on. It is important to use the readings and examples to learn from past errors and add in additional features.

Analysis of Reviews

As these articles were reviews, rather than experiments, much analysis of their methods cannot be done. Heitmiller gave many examples of both successful and unsuccessful checklists, but did not go into much detail as to why the unsuccessful checklist examples failed in use.

Hales gave a detailed description of her approach to find relevant literature. Although she was unable to find many strategies to develop checklists and found no standardized methodologies, she was able to identify several important steps in developing effective checklists in the medical field. Hales systemic approach has not yet been validated.

Boorman gave many examples of advantages, as well as problems with ECLs. He also discussed the best way to avoid these problems.

Importance of Effective Checklists and Future Implications

Based on these reviews, there is clearly a significant need for checklists in the medical field. Checklists are an important tool used to condense large quantities of knowledge in a concise fashion, reduce the frequency of errors of omission, create reliable and reproducible evaluations, and improve quality standards and use of best practices.

There is much potential for ECLs to ease the use of checklists and further reduce error.

Finally, we must think about the checklists impact on electronic health records and other equipment and how to incorporate them. Currently, all patient care facilities are in the process of switching from paper based health records to electronic records. With this comes the opportunity to easily move data from an electronic checklist to and electronic health record, but this raises additional issues including errors in the system and patient privacy.