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The checklist—a tool for error management and performance improvement

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Abstract Levels of cognitive function are often compromised with increasing levels of stress and fatigue, as is often the norm in certain complex, high-intensity fields of work. Aviation, aeronautics, and product manufacturing have come to rely heavily on checklists to aid in reducing human error. The checklist is an important tool in error management across all these fields, contributing significantly to reductions in the risk of costly mistakes and improving overall outcomes. Such benefits also translate to improving the delivery of patient care. Despite demonstrated benefits of checklists in medicine and critical care, the integration of checklists into practice has not been as rapid and widespread as with other fields. This narrative is a guide to the evolution of medical and critical care checklists, and a discussion of the barriers and risks to the implementation of checklists.

1. Introduction

Human error is inevitable—particularly under stressful conditions [1,2]. It has been demonstrated that levels of cognitive function are compromised as stress and fatigue levels increase [3], as is often the norm in certain complex, high-intensity fields of work. This can lead to increased errors in judgment, decreased compliance with standard procedures, and decreased proficiency. Areas such as aviation, aeronautics, and product manufacturing, in which safety and precision are paramount in accurate service delivery, have come to rely heavily on simple tools to aid in reducing human error. An important tool in error management across all of these fields is the checklist, a key instrument in reducing the risk of costly mistakes and improving overall outcomes.

A checklist is typically a list of action items or criteria arranged in a systematic manner, allowing the user to record the presence/absence of the individual items listed to ensure that all are considered or completed. A sound checklist highlights the essential criteria that should be considered in a particular area. Checklists can differ from other cognitive aids or protocols in that they lie somewhere in between an informal cognitive aid, such as a Post-It note or a string around your finger, and a protocol, which typically entails mandatory items for completion to lead the user to a predetermined outcome. Checklists can provide guidance to a user and act as verification (a "check") after completion of a task, without necessarily leading users to a specific conclusion.

Checklists can have several objectives, including memory recall, standardization and regulation of processes or methodologies, providing a framework for evaluations or as a diagnostic tool [4]. However, regardless of the nature of the checklist, the principal purpose of their implementation is

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commonly error reduction or best practice adherence. Their efficacy as a cognitive aid likely lies in their ability to use the theories of "category superiority effect" or "chunking" where grouping relational or item-specific information in an organized fashion can help to improve recall performance [5,6]. List instructions are also often better understood and recalled than information in paragraph format [7].

Of the literature available regarding the use of checklists in industry, the focus lies heavily on aeronautics and aviation, manufacturing quality control, and, to an evolving extent, healthcare. This review will highlight the main areas in which checklists are already used most consistently, their specific contributions to that field, and their transition into the healthcare arena.

2. Aviation

The majority of literature published to date regarding the use of checklists in the workplace focuses on aviation and aeronautics. Primarily because of the high-risk environment in which pilots and astronauts find themselves, these industries have adapted both paper and electronic checklist as tools to help decrease human error.

This profession has recognized the likelihood of human error to occur under daily work conditions. For this reason, all pilots, from Air Force aviators to recreational pilots, universally use checklists before, during, and after flights. The use of these checklists is highly regulated in aviation and under most circumstances is considered a mandatory part of practice. Under these circumstances, the checklist becomes flight protocol, and completion of a checklist from memory is considered a protocol violation or pilot error [8]. There are several examples of normal checklists that are an integral part of regular flight practices including preflight checks, cockpit checks, starting engine checks, landing, and shutdown checklists, to delineate a few [9]. These normal checklists are the basis of flight protocols and make up the majority of activities throughout the process. They act as verification or "check" of items completed (redundancy) to ensure errors are avoided. Checklists are also used in nonnormal or emergency situations, including checks for ground operation emergencies, take-off emergencies, ejection procedures, landing emergencies, fuel system failures, and countless others [9-11]. As these are used to guide the correction of error situations, they may not be considered part of the normal flight protocol; however, under emergency circumstances, completion of the checklist becomes the protocol for troubleshooting or problem solving, providing a systematic approach to emergency situation recovery.

Best practices for aviation maintenance have been determined based on repeated safety surveys, and several checklists have been developed to aid users in maintaining these practices during flights. Examples of available best practice checklists put forth primarily by the Naval Safety Center of the United States Navy include Line Division Safety Check-Ins; Weekly, Monthly, and Quarterly Checks; Aircraft Condition Sign or Checklist; Aircraft Director's Checklist; Maintenance Standard Operating Procedure Checklist; Safety Walk-Through Checklist, etc. [12]. Several other checklists have been implemented as part of the Safety Center's 50-Percent Reduction Plan, a performance improvement and safety initiative through which the Navy and Marine Corps aim to reduce adverse events and mishaps by at least 50% (www.safetycenter.navy.mil/).

Several aircraft manufacturers have also undergone the transition from paper-based to electronic checklist systems to update their regular practices and take advantage of functional design benefits that this technology can provide. The Boeing 777 Electronic Checklist for example was developed in the early 1990s as a new flight deck automation tool to help guide pilots through both normal and emergency (nonnormal) processes before, during, and after flights [10]. Implementation of this newer checklist technology decreased errors by an additional 46% as compared to paper-based checklists alone [10].

Pilots complete checklists not only to monitor the status of their procedures and equipment, but also themselves. The IM SAFE checklist (Illness, Medication, Stress, Alcohol, Fatigue/Food, Emotion) allows pilots to go through a qualitative evaluation of their physical, mental, and emotional status before embarking on a flight [13,14]. This checklist is completed regularly as part of the overall preflight risk management assessment to prevent pilots from operating an aircraft under suboptimal conditions.

Errors during flight not only place passengers at risk, but also the pilots and crew. This very real threat to personal safety within the profession may be an important component of the speed and success of the aviation industry in implementing safety improvement measures. Although excessive use of checklists might contribute to "checklist fatigue" if they were designed for every decision required during a flight, their presence as a safety measure contributes to the control of unpredictable human factors that will influence the pilots' performance and thus the safety and outcome of the flight.

3. Product manufacturing

In industries such as product manufacturing, where the smallest error in the development or production process can endanger the public and increase manufacturing costs, error management is vital. For fields in which a governing regulatory body monitors the quality of the output, checklists are integral in ensuring the proper operating procedures are followed and the standards of quality are upheld.

Although several processes are highly monitored, including automobile or food manufacturing, the production of pharmaceuticals and medical devices has particularly stringent quality control requirements. For this reason, governing bodies such as the Food and Drug Administration

in the United States and the Therapeutic Products Directorate in Canada use multiple checklists at all stages of drug or device development, from preclinical phases, to postmarketing phase IV studies, to the manufacturing process itself.

Not only are the manufacturing processes tightly regulated for quality purposes, but several screening checklists also exist to assess associated matters such as the various checklists for evaluating compliance of local institutional review boards, the checklist used by the Canadian Food Inspection Agency to assess the evidence-based nature of pharmaceutical advertising [15], or the Food and Drug Administration checklist for evaluating protocols of the Radioactive Drug Research Committee [16].

Quality assurance personnel must use checklists at several stages to ensure that products are up to quality regulations, and that the overall manufacturing process itself continues to achieve required standards for distribution to the public. Many companies will design checklists to specifically encompass the requirements of control boards such as the Hazard Analysis and Critical Control Point system or the universally used Good Manufacturing Practices. The Canadian federal government provides companies with audit checklists to evaluate whether their basic standard operating procedures adhere to regulations of the quality control authorities and whether they will eventually produce an acceptable product [17].

These checklists have become the most important part of the standard operating procedures and in several instances have become requirements in reducing errors, evaluating processes, and upholding high-quality production standards leading to decreased risk to the general public.

4. Healthcare

The Institute of Medicine estimates that medical errors cause between 44 000 and 98 000 deaths annually in the United States alone, resulting in US$17 to 29 billion in costs annually [18]. This same report comments on the delay by the healthcare industry in adopting the same rigorous error management precautions and attention to ensuring basic safety as compared to other high-intensity areas such as aviation. The Institute of Medicine is certainly not the first organization or healthcare provider to draw comparisons between these industries, nor are they the first to express their opinion that healthcare is behind in adopting these simple policies [1,8,13].

Checklists have contributed to prevention of error under stressful conditions, maintenance of precision, focus, clarity, and memory recall. Although pilots are expected to use their professional judgment and critical thinking skills, they are also provided with tools to aid them in recalling the masses of catalogued information at the appropriate time. If pilots are not expected to recall from memory each crucial step of their complex tasks—why is this required of clinicians who are also responsible for the lives of others? Is the aviation industry willing to take these extra measures because their own lives are put at risk by their performance?

Healthcare organizations have already begun to follow the lead of the aviation industry by applying the theories of crew resource management to improve patient safety by promoting teamwork and communication among care teams [19] yet the theories of checklist implementation and error management to achieve these goals are still incompletely followed. Unlike federal aviation regulations, which firmly enforce the use of checklists throughout the flight process, healthcare is far less regulated. The enforced standardization of processes, to which mandatory checklist completion can be applied, is a far more difficult task in medicine than aviation, given the unpredictability of human physiology.

Regardless of the context in which checklists have been used, their ultimate goal has been controlling and reducing error, particularly human error. When extrapolated into the medical context, error reduction can correlate directly with improvements in patient outcomes, patient safety, and efficacy of resource utilization. Examples of checklists have already been demonstrated to be effective in select, high-intensity fields of medicine, such as trauma and anesthesiology [20-23]. A study by Wolff et al [24] used daily checklists and reminders in clinical care pathways for inpatients admitted for acute myocardial infarction or stroke, which led to significant improvements in compliance with various key best practices such as administration of aspirin in the emergency department, receipt of β-blockers within 24 hours of admission, dysphagia screening within 24 hours of admission, and administration of aspirin or clopidogrel to ischemic stroke patients within 24 hours of admission, as compared with the period before the study. Despite as much as a 55% improvement in some of these primary outcomes after the implementation of the checklists and memory aids in the care of regular hospital inpatients [24], checklists are not routinely used in this clinical setting.

As previously discussed, regulation or enforcement of checklist use in healthcare would likely be extremely difficult to achieve. Several barriers, both operational and cultural, exist to the use of these types of tools. Operationally speaking, it is extremely difficult to standardize certain processes in medicine largely because of variations in the patient population. Unforeseen adverse events, concomitant conditions, and other unpredictable human factors can influence the approach to treatment therefore making the design and implementation of a standardized checklist exceedingly challenging. Culturally, there is often an assumption that the use of memory aids is an admission of weakness or lack of medical skill or knowledge, which can contribute to negative attitudes toward the implementation of these types of resources. Furthermore, clinicians often view standardization, or the use of standardized tools such as checklists, as a limitation to their clinical judgment and autonomous decision making. As such, despite their demonstrated benefits, the integration of checklists into medical practice has not been as rapid and widespread as with other similar fields.

5. Critical care

Checklists have slowly begun to make their way into the field of critical care medicine. Checklists may be particularly relevant to critical care, as the complexity of medical conditions seems to be increased in this environment.

Certain procedures or diagnoses that have been targeted for the use of checklists have shown significant improvements in outcome. After the implementation of a checklist to standardize the withdrawal-of-life-support process in two teaching hospital tertiary care medical-surgical intensive care units (ICUs), approximately 80% of nurses believed the checklist led to improved end-of-life care and withdrawal of life support [25]. It was also shown that significantly fewer patients received inappropriate use of resuscitation measures or comfort medications in the 12-hour period before death [25]. A study by Walsh et al outlined that the use of a checklist assessing specific eligibility criteria for mechanically ventilated patients can help to predict successful weaning from the ventilator and lead to earlier liberation from mechanical ventilation [26]. In this instance, 83% of the patients who were successfully weaned from the ventilator met the checklist criteria, which was determined to be a moderately strong predictor of ultimate ventilator independence. The checklist exhibited a specificity of 89%, positive predictive value of 94%, and positive likelihood ratio of 7.6 [26]. An Intensive Care Delirium Screening Checklist proved to be effective in identifying patients who would develop delirium. Of the patients included in this study, 93% of patients having developed delirium obtained a significantly high score on the screening checklist, whereas only 19% of patients having not developed delirium had similar scores (sensitivity, 99%; specificity, 64%) [27]. There are several other examples of checklists contributing solely or in part to improved patient outcomes in the critical care arena, including checklists for effective transfers of spinal cord injury patients out of the ICU [28], intensive care room opening checklist [29], and a checklist for effectively diagnosing brain death [30].

More recently, evidence-based best practices have been targeted on checklists. Practices previously shown to improve patient outcomes are not always necessarily translated to the bedside. The use of a checklist as part of a multifaceted intervention for improving the overall care of mechanically ventilated patients led to a 66% improvement in the use of evidence-based best practices when compared with the period before the study [31]. When using similar strategies involving checklists to target the prevention of catheter-related bloodstream infections, this same research group was able to demonstrate a decrease in the catheter-related bloodstream infection rate from 11.3/1000 to 0/1000 catheter days over the course of the study period [32].

Implementation of daily "goals checklists" for critical care patients has shown improvements in overall patient outcomes and decreased length of stay in the ICU. A surgical ICU team at Hartford Hospital was able to demonstrate a decrease in mortality rates from 11.4% to 8.3% after the implementation of their checklist as well as a decrease in the average ICU length of stay by 1.5 days and ventilator days by 1 day [33]. Their form was based on that of Pronovost et al who showed a 50% decrease in ICU length of stay after the introduction of their checklist of daily goals along with an 85% improvement in clinicians understanding of the daily care goals for each patient [34].

There may be risks associated with the overuse of checklists, particularly in the medical setting. Checklist "fatigue," whereby the overwhelming number of available or required checklists becomes a hindrance rather than an aid, is becoming a more common theme in areas that have been heavily targeted with this type of intervention. If overused, rather than supporting clinicians, checklists can act to impede the quality and speed of service delivery. Checklist users may also become dependent on these tools in their practice, which can interfere both with their professional judgment and the objectivity of their decision-making processes. It is important that checklist development and implementation within an organization be monitored for quality and necessity to avoid overburdening staff. Checklists should also be evaluated for their impact on healthcare service delivery before implementation to validate the requirements for that type of tool in any given clinical environment.

6. Conclusion

In industries where the welfare of a human being is at risk, checklists can help to ensure that performance and safety standards are met. Where products are manufactured, landings and takeoffs are required, evaluations are performed, or medical procedures are carried out, evidence indicates that checklists may reduce errors, improve safety, and improve outcomes. As patient safety and performance improvement become a stronger focus of the medical profession, the use of simple tools for error reduction such as checklists may contribute to better patient outcomes and safety, more effective practices, and more effective use of allocated funds and resources.

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