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Editorial

EDITORIAL

Checklists, cognitive aids, and the future of patient safety

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On Wednesday, October 30, 1935, an evaluation flight of the Boeing Model 299 was undertaken at Wright Field, northeast of Dayton, OH, USA. The Model 299 was the most technologically sophisticated aircraft of its time and was nicknamed the Flying Fortress because of the extent of its armaments. Major Ployer P. Hill was the pilot, and it was his first flight in the new aircraft. The aircraft appeared to ascend normally, but suddenly stalled, turned on one wing, and crashed, killing two of the aircraft's five crew, including Major Hill. The investigation into the crash discovered that Major Hill had omitted a crucial step during the preflight preparation; he forgot to release a catch, which on the ground locked the aircraft's control flaps.[1] Once in the air, this mistake rendered the aircraft uncontrollable. The crash investigators knew that there was probably no one better qualified to fly the new aircraft than Major Hill—his co-pilot was also highly qualified—yet despite this, the fatal error was still made. The investigators concluded that given the experience of the pilots, further training would not be an effective response to prevent such an event from happening again; a response that is very different from that which often occurs in health care when a mistake is made.[2] Some commentators initially believed that this meant the new aircraft was simply too complicated to fly reliably. A new approach was needed, and it took the form of a simple list of crucial tasks that must be completed before the aircraft could leave the ground. The first aviation checklist had been devised.[1] With the checklist in use, despite the aircraft's sophistication, the Model 299 (and later versions of it) performed safely for many years.

Around 70 yr later, the crash of the Model 299 and creation of the aviation checklist were the inspiration for the development of the now celebrated World Health Organization (WHO) Surgical Safety Checklist.[1] The technical issues for surgical safety were similar to those in aviation; highly qualified and skilled clinicians working in the high-technology environment of the operating room needed to ensure that certain crucial steps were not omitted during a procedure. The WHO Surgical Safety Checklist was therefore designed to improve team communication and consistency of care by prompting checking and communication at crucial points. In a large-scale multinational study of 7688 patients reported in 2009, use of the WHO Surgical Safety Checklist was shown to reduce the overall rate of postoperative complications by 36%.[3] In the succeeding years, there have been a flurry of safety checklist studies, which have included the emergence of a better understanding of the limitations of the use of checklists in surgery and health care.[4–7]

One substantial limitation of applying aviation-type checklists in health care is the fact that although aircraft are complicated, patients undergoing health care are complex.[2 8 9] The challenge of patient variability should not be underestimated. Unlike many high-technology endeavours where a great deal of standardization is possible, health care clearly must contend with the subtle physical variations and abnormal anatomies and pathologies that exist in individuals; differences that are often unknown and unknowable before the procedure has begun. This represents a different situation from that with a machine, such as an aircraft, where its exact structure and function is known and where these details are documented. Checklist design for aircraft, where the vast majority of eventualities can be anticipated, is therefore a relatively simpler task than attempting to adopt the same approach in health care.

However, despite such limitations, systematic reviews of the use of safety checklists in the operating room demonstrate their substantial benefits in terms of improving patient outcomes, but only when teams engage with the checklist process and when compliance with checklist items is high.[10–15] One study found no improvements in postoperative survival rates when checklists were not completed or when completed only in part, but showed significant survival benefits when checklists were fully completed.[16] Checklist design is not a trivial process. The checklist should be short; its design must be based on the best clinical knowledge, and it must not be influenced by managerial concerns regarding the medico-legal protection of the organization.[1 17 19] A formal process for the introduction of a safety checklist is typically needed so that clinicians know how the checklist should be used.[4 7] Engagement by key team personnel is also important to establish a safety culture that encourages and maintains compliance with the checklist for every patient.[5 18]

The article by De Bie and colleagues[20] in this issue of the *British Journal of Anaesthesia* describes an *in situ* simulation study of a new electronic dynamic clinical checklist (DCC), which contains two significant innovations with the potential to solve a number of important problems in the successful use of checklists in health care and to advance patient safety more widely.[21 22] These innovations are as follows: (i) meaningful sharing and integration of information between multiple hospital systems; and (ii) automatic preparation of a personalized electronic checklist of items relevant to the care of each individual patient. The DCC system achieves this by using a set of algorithms to select checklist items relevant to each patient in the intensive care unit based on information accessed from the patient's electronic health record, the hospital's treatment protocols, and pharmaceutical databases. The algorithms can also automatically check certain items when the system has access to the relevant information, hence reducing the checklist burden on the clinician. Comparing the use of their hospital's standard paper-based checklist with the new DCC during 116 *in situ* simulations demonstrated an increase in completion rate of checklist items from 74 to 100%. Participants rated their satisfaction with the DCC highly and agreed that the approach had potential in medical care. In addition, follow-up by the pharmacist after the simulated ward round, as prompted by alerts from the hospital's clinical decision support system, reduced dramatically from 80% to only 3.6% with use of the DCC. The use of simulation is becoming more common for the purposes of evaluating new safety interventions and in making inferences about team behaviour in the clinical setting.[23] Given the evidence that compliance with checklists is an essential part of their effectiveness in improving patient outcomes, we might therefore expect the DCC to have substantial potential to improve clinical care in the intensive care unit, and I look forward to these clinical studies.

Many hospital systems and devices currently have some facility for sharing certain information with other devices, but few have achieved the kind of meaningful, safety-orientated integration that is reported here with the DCC. One potential risk of the success of the WHO Surgical Safety Checklist is that the use of checklists has now become so widely mandated throughout health care that poorer quality checklists may be introduced into use, and checklists may be introduced into practice areas where they are less effective; both outcomes are likely to lead to disengagement by clinicians.[9 24 25 26] In contrast, allowing the algorithms of the DCC to access all relevant data when generating checklist items for individual patients means that the resulting personalized checklist is immediately relevant to the patient's care. Unlike a paper-based or static checklist, non-relevant or generic checklist items need not appear on the DCC. From a psychological perspective, the salience of any message or signal is determined by its informational content or informativeness, hence messages that contain misinformation or false alarms tend quickly to be ignored.[27] Therefore, a checklist with few or no generic items would be expected to be more salient for the user. As the authors state, in this sense the DCC is a true cognitive aid, in that it supports and assists the clinician in getting his or her job done, rather than potentially being viewed as a mandatory requirement, of variable relevance, that might add further burden to their existing workload. The DCC is therefore likely to engage clinicians better and to encourage them to check every item, as occurs during every flight with an aviation checklist. Further research considering what happens to clinicians' work patterns when the DCC is used in the clinical setting and whether it has indeed become integrated into their workflow will be interesting, particularly given that conversion of other formerly physical records into electronic formats (e.g. radiographs and patient notes) has often had unanticipated consequences.[22]

I was interested that the feature which allows certain checklist items to be completed automatically by the DCC could be overridden by clinicians, if they preferred to complete such a check themselves. The tailoring of the set of algorithms of such a dynamic checklist system is clearly important for many reasons; in order to adjust sensitivity to the kinds of events that clinicians want to monitor, to update the checklist items when clinical knowledge changes, and to customize the checks for particular patient populations or clinician preferences. If systems such as the DCC become more widespread, I expect that additional work will be done to fine-tune the algorithms that generate the checklists. This work could determine what kinds of information the checklist algorithms need to access to make the best checklists, and what the optimal hierarchy or prioritization of checklist items might be to produce a checklist that tells you all you need to know but isn't too long. Electronic systems, such as the DCC, make it easy to update such features, because like all software, updates can propagate out from a central location to all devices in the network, and there will be no physical copies of the old version of the checklist to remove from use.

The DCC represents an example of a system where electronic clinical information has been meaningfully synthesized from various hospital systems, and non-relevant information has been filtered out. I believe such an approach will have many applications in the improvement of the quality and safety of patient care in the near future, particularly if we are indeed at the dawn of medicine's computer age.[21 22 25]

One pressing area of need for such an approach is that of alarm management in operating rooms and intensive care units, and this is an area where health care could again benefit from the techniques used in aviation. The functional integration possible in many clinical devices is currently limited and hampered by various different proprietary formats and standards. The practical consequence of this is that many devices, from drug infusion pumps to patient monitors, generate their own stream of alerts and alarms independently of each other, without any co-ordination or prioritization, leading to a cacophony of auditory alerts where important alarms can be lost amongst trivial ones. This leads to alarm fatigue, where alarms may be ignored or switched off. A recent study of this problem reported from a single hospital, with 77 intensive care beds, recorded the occurrence of an astonishing 2 558 760 unique physiological alarms during intensive care in a single month.[28] In aviation, the alarm fatigue problem is managed by engineers and pilots working co-operatively to agree upon exactly what needs to be alerted to the pilot from all aircraft systems and what does not. Agreed alarms are then placed in a hierarchy, with many events being reported only as 'cautions' or 'advisories' on a screen, but without any auditory alert. Pilots would not tolerate the alarm chaos that clinicians currently face. Even an event as apparently serious as an engine failure in a multi-engine aircraft will not result in a top-level alarm with an auditory alert, but only a caution. This is because such an event does not require immediate pilot intervention owing to the automatic systems on modern aircraft.[22] The manufacturers of components for aircraft cockpits must meet very specific compatibility standards, but at present this is not the case in health care. Although checklists, either dynamic or otherwise, are a successful approach to align and increase the consistency of key procedural aspects of patient care, such alignment needs to extend beyond procedures to include the equipment used in clinical environments.[29]

We know that paper checklists, when well designed, properly introduced, and complied with, can substantially reduce the burden of postoperative complications. The electronic DCC reported in this issue of the *British Journal of Anaesthesia* represents an important development beyond paper or static checklists, in that the checklist is automatically tailored to each patient by drawing on various sources of patient data. The results of a simulation study in the intensive care unit are encouraging, including excellent checklist compliance. The next step will be clinical trials of the DCC in order to determine whether the excellent compliance rates seen in the simulator translate into improvements in the safety and quality of patient care. The information filtering and prioritization features of a dynamic checklist also seem highly suitable for solving other difficult problems in health care, such as the alarm management problem.

Declaration of interest

The author owns a small number of shares in SaferSleep Ltd, a company that aims to improve safety in health care.

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