

of anesthesiologists.<sup>5</sup> Nonetheless, we agree that our goal should always be focused on improving patient care, not on test scores *per se*. This study focused on whether knowledge acquisition was accelerated with the advent of the BASIC examination, not on whether the ultimate clinical performance of residency graduates is improved (an important question that remains to be answered in future research). We very much agree that changes such as the staged examination system, including the introduction of the Objective Structured Clinical Examination (also mentioned by Dr. Berman), require continued evaluation. As evidenced by this and other publications, the American Board of Anesthesiology is committed to ongoing rigorous and transparent analyses of its systems and processes. These analyses include evaluation of the unintended consequences on our trainees and, ultimately, on the abilities of anesthesiologists to provide excellent patient care. Such analyses will be essential to the consideration of any future system and process modifications desired to better meet the goal of fulfilling the American Board of Anesthesiology's mission to advance the highest standards of the practice of anesthesiology. We thank the authors of the letters for their comments, and we welcome further feedback from the community of anesthesiologists whom we serve.

### Competing Interests

Drs. Sun and Zhou are staff members of the American Board of Anesthesiology; Drs. Keegan and Warner are American Board of Anesthesiology directors and receive a stipend for their participation in American Board of Anesthesiology activities; Dr. Lien is a former director of the American Board of Anesthesiology.

**David O. Warner, M.D., Yan Zhou, Ph.D., Mark T. Keegan, M.B.B.Ch., Cynthia A. Lien, M.D., Huaping Sun, Ph.D.** The American Board of Anesthesiology, Raleigh, North Carolina (H.S.). huaping.sun@theABA.org

### References

1. Zhou Y, Sun H, Lien CA, Keegan MT, Wang T, Harman AE, Warner DO: Effect of the BASIC examination on knowledge acquisition during anesthesiology residency. *ANESTHESIOLOGY* 2018; 128:813–20
2. de Oliveira GS Jr, Chang R, Fitzgerald PC, Almeida MD, Castro-Alves LS, Ahmad S, McCarthy RJ: The prevalence of burnout and depression and their association with adherence to safety and practice standards: A survey of United States anesthesiology trainees. *Anesth Analg* 2013; 117:182–93
3. Royal College of Anaesthetists: A report on the welfare morale and experiences of anaesthetists in training: The need to listen. Royal College of Anaesthetists, London, UK, December 2017
4. McClintock JC, Gravlee GP: Predicting success on the certification examinations of the American Board of Anesthesiology. *ANESTHESIOLOGY* 2010; 112:212–9
5. Zhou Y, Sun H, Culley DJ, Young A, Harman AE, Warner DO: Effectiveness of written and oral specialty certification examinations to predict actions against the medical licenses of anesthesiologists. *ANESTHESIOLOGY* 2017; 126:1171–9

(Accepted for publication August 31, 2018.)

## When Checklists Fail: Human Factors Learning from Aviation and Safety by Design

*To the Editor:*

There has been appreciable literature on the use of checklists to prevent errors that could lead to patient harm.<sup>1</sup> In this letter, we use a recent commercial aviation event to explore the limitations of checklists and introduce the concept of engineering design to prevent error, and examine parallels in health care. In April 2018, following a cabin depressurization on Southwest Airlines, images were posted online showing passengers wearing oxygen masks incorrectly, covering their mouths only. This provoked debate blaming passengers for not listening to the preflight briefing during which the instructions, “place the mask over your nose and mouth and breathe normally,” are given.<sup>2</sup> There are many reasons why this simplistic analysis of the error and blame is counterproductive, and why other solutions, such as engineering safety into the design of the oxygen masks, are more likely to succeed than using checklists alone. The Southwest Airlines preflight announcement<sup>2</sup> is a checklist that imparts 34 pieces of information, providing a high cognitive load in a situation in which other distractions and anxiety may be present. Only exceptional individuals have a working memory that tolerates retention of more than half a dozen pieces of information. Information retention of frequent flyers may be blunted over time due to a phenomenon known as “creeping complacency” and “alert/warning fatigue.” We propose a simple, safety-design engineered solution for these rare events to improve compliance. Currently the airline oxygen mask is cylindrical with a round aperture. The elongated shape of a simple face mask and its elastic strap, however, can be presented to unaccustomed users in the correct vertical orientation, providing the visual and haptic signals to nudge appropriate placement covering the nose and mouth.

Similar rare events in health care are “serious adverse events” or “never events.” Despite the introduction of education and checklists, the incidence of reported never events has increased. With rare but serious errors, the same problems of cognitive load, creeping complacency, and alert/warning fatigue come into play. The additional time and cognitive load upon an operator, performing complex procedures in distracting and stressful environments, from the use of formalized checklists, may be detrimental. This may have a greater overall absolute negative impact for the thousands of uncomplicated procedures outweighing the benefit of preventing a single rare error. Two-person checks are commonly instituted for preventing rare errors. However, distraction and creeping complacency manifest here, wherein both operators tend to rely on the other to complete the procedure correctly, along with inattentional blindness in which the checkers see what they expect to see, rather than what is in plain sight. Warning fatigue is commonplace and

particularly problematic for rare events. For rare errors, an engineered solution in equipment design not only prevents the error but sustains the safety benefit over time. Through the introduction of simple design adaptations in health care, it may be possible to make specific rare serious events either less likely or impossible when checklists or human practice fail.

### Research Support

Dr. Mariyaselvam is undertaking an M.D. in Human Factors under the supervision of the University Department of Anaesthesia, University of Cambridge, Cambridge, United Kingdom.

### Competing Interests

The authors declare no competing interests.

**Maryanne Z. A. Mariyaselvam, M.B.B.S., Peter J. Young, M.D.** University of Cambridge, Addenbrooke's Hospital, Cambridge, United Kingdom (M.Z.A.M.). m.mariyaselvam@nhs.net

### References

1. Gillespie BM, Chaboyer W, Thalib L, John M, Fairweather N, Slater K: Effect of using a safety checklist on patient complications after surgery: A systematic review and meta-analysis. *ANESTHESIOLOGY* 2014; 120:1380–9
2. Southwest Airlines pre-flight public announcements: Transcription of opening, emergency, service, final descent and arrivals announcements. <https://quizlet.com/36754761/pas-for-swa-flash-cards/>. Accessed May 3, 2018

*(Accepted for publication September 6, 2018.)*

---