

Reducing Health Care Hazards: Lessons From The Commercial Aviation Safety Team

A proposed public-private partnership to help the health care community emulate the successes of CAST in commercial aviation.

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ABSTRACT: The movement to improve quality of care and patient safety has grown, but examples of measurable and sustained progress are rare. The slow progress made in health care contrasts with the success of aviation safety. After a tragic 1995 plane crash, the aviation industry and government created the Commercial Aviation Safety Team to reduce fatal accidents. This public-private partnership of safety officials and technical experts is responsible for the decreased average rate of fatal aviation accidents. We propose a similar partnership in the health care community to coordinate national efforts and move patient safety and quality forward. [*Health Affairs* 28, no. 3 (2009): w479–w489 (published online 7 April 2009; 10.1377/hlthaff.28.3.w479)]

FAR TOO MANY PEOPLE SUFFER PREVENTABLE injuries from health care in the United States. In 2000 the Institute of Medicine (IOM) called for a 50 percent reduction in preventable patient harm within five years.¹ Since then, awareness of patient safety has increased among consumers and providers, and the movement to improve quality of care and patient safety has expanded. Yet exam-

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ples of measurable and sustained progress are rare.² Despite substantial efforts to prevent medication or device errors and wrong-site surgical procedures, these events continue seemingly unabated. Patients suffer recurrent “sentinel events” (defined by the Joint Commission as “unexpected occurrence[s] involving death or serious physical or psychological injury, or the risk thereof”) even after hospitals conduct root-cause analyses and implement interventions to mitigate identified risks.³ Although the ambitious goal outlined by the IOM is laudable, health care lacks a clear strategic plan and mechanisms to reach it.

Health care’s slow and disappointing efforts to improve safety contrast with the remarkable success of aviation safety. Building upon an already enviable record of safety, the Commercial Aviation Safety Team (CAST) was voluntarily formed in 1997. The initial goal of this public-private partnership was to reduce the U.S. commercial aviation fatal accident rate by 80 percent within ten years. Between 1994 and 2006, the average rate of fatal accidents decreased from 0.05 to 0.022 per 100,000 departures. CAST has now expanded globally.⁴

Health care can learn many important lessons from aviation. Those most relevant to CAST are to standardize work processes, use checklists to ensure that patients receive evidence-based interventions consistently, improve teamwork and communication to reduce errors, and use robust scientific methods in collaborative efforts to identify and mitigate risks. A number of efforts inspired by the first three aviation lessons are under way in hospitals.⁵ The fourth lesson, so masterfully demonstrated by CAST, is one that the health care field should also emulate. In this paper we explore how CAST and the health care field learn from mistakes, and we outline how the health care community can create the equivalent of CAST to improve patient safety dramatically.

Background: Accidents In Commercial Aviation

Several days before Christmas 1995 at 6:30 p.m., after a two-hour delay, American Airlines Flight 965 departed Miami, Florida, en route to Cali, Colombia. Around 9:30 p.m., while descending from an altitude of 20,000 feet, the crew contacted Cali air-traffic control (which had no radar) for landing instructions. The flight crew expected to land on runway 1, which required flying south past the airport and doubling back. After the pilot initiated the plane’s approach to runway 1, the Cali approach controller suggested a last-minute change to runway 19 to save several minutes. The speed and altitude of the Boeing 757 were too high for this new approach, so the first officer deployed the speed brakes.

Air-traffic control cleared the flight for a straight-in approach to runway 19, instructing the crew to use a nondirectional radio beacon named Rozo to guide their flight. The crew did not realize that Cali’s paper-based approach charts and the aircraft’s flight-management computer database used the same code and frequency for two different navigational beacons: Rozo and Romeo. The crew dialed “R” for the Rozo beacon. However, when the code was entered into the computer,

the aircraft automatically initiated a turn to the left, heading toward navigational radio beacon Romeo. The Romeo beacon was 150 nautical miles from Cali runway 19. This turn caused confusion in the cockpit, since air-traffic control had described a straight approach to the runway. Eighty-seven seconds after commencing the turn, the crew realized what had happened and started a right turn back toward Cali. The faulty left turn had positioned the Boeing 757 over mountains, so turning back at their now lower altitude activated the ground proximity warning system. The crew attempted to climb, but the speed brakes were still activated. The aircraft crashed into a mountain at about 8,900 feet. All eight crew members and 160 of the 164 passengers perished.⁶

The crash of Flight 965 was one of many controlled flight into terrain (CFIT) accidents that pressured the aviation industry to reduce accident risk. A CFIT accident occurs when the flight crew inadvertently flies a perfectly functioning aircraft directly into the ground or water. The CFIT accidents prompted the White House and Congress in 1996 to recommend collaborations between the aviation industry and government, to reduce the risk of aviation accidents.

CAST brought the entire aviation industry together, from major manufacturers, airlines, and labor organizations to government agencies such as the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), and Department of Defense (DoD), and international organizations such as the Flight Safety Foundation. Member organizations agreed that a representative from industry and the government would serve as CAST's cochairs. In addition, a senior official from each member organization with the authority to commit his or her organization to specific actions serves on an executive committee.

Indeed, CAST has demonstrated that government and industry can work together to solve important problems. They can undertake extensive analysis of accidents and incident data and identify major risks, and can develop detailed implementation plans in which specific sectors of aviation commit to defined actions. CAST chartered several working groups to conduct analyses of fatal accident categories, develop "intervention strategies" to eliminate or greatly reduce such accidents, and to prioritize and coordinate plans to implement those strategies.

Organization And Procedures For CAST

CAST meetings are held in Washington, D.C., and are attended by members of the executive committee. The CAST cochairs oversee activities of the two main working groups (Joint Safety Analysis Teams and Joint Safety Implementation Teams), which contain multiple teams of technical experts. Each analytic team is charged with conducting in-depth analyses of a particular accident category. They review accident investigation reports from authorities such as the National Transportation Safety Board and incident (errors that did not lead to harm) data from similar events. Next, the team establishes a detailed sequence of events for each accident in this category to define the problems (what went wrong) and the con-

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tributing factors (why they went wrong), some of which might not be explicitly noted in an accident report. They rate each problem and contributing factor on their level of confidence that each played an important role in causing the accident (power 1) and on the probability that each could cause future accidents. Based on this analysis, the team develops possible interventions and evaluates how well the intervention solves the problem or mitigates the contributing factors (power 2) that resulted in the accident, and whether they perceive that the intervention will be executed as intended. The team uses a seven-point Likert scale (from 0, not confident, to 6, highly confident) to rate power and confidence.

Finally, an implementation team assesses the feasibility (including technical, financial, operational, schedule, regulatory, and sociological) of implementing each recommendation of the analytic team, and it devises a plan to implement the strategies. After interim reviews and approvals by the executive committee, recommendations are grouped into strategies, with detailed implementation plans that define the precise actions to be taken by whom and when, and an estimated cost.

The first analysis team chartered by CAST examined CFIT accidents, such as that of Flight 965. Between 1995 and 2004 there were twenty-two CFIT accidents with 1,999 fatalities worldwide.⁷ A twenty-three-member team completed its analyses after devoting thirty days to the CFIT project (October 1998). A common contributing factor was loss of situational awareness, in which the crew loses awareness of the plane’s location over the earth and of its speed and descent rate.

The first implementation team made multiple recommendations that led to the commercial development and adoption of several technologies designed to prevent or mitigate CFIT accidents. These included installing the terrain awareness and warning system in all registered aircraft in the United States and installing the minimum safe altitude warning system in ground radar systems. In addition, industry and regulatory agencies within CAST created and facilitated widespread adoption of training standards. Globally, there were zero CFIT accidents in 2004. Since then, every CFIT accident has involved aircraft without the terrain awareness and warning system installed. This dramatic improvement in aviation safety is the result of robust, data-intensive, focused, coordinated, and disciplined efforts to identify and mitigate risks.

CAST is funded by members’ donations of expertise, time, and travel costs. Analysis and implementation team members devote approximately one week a month to identifying and mitigating hazards. On average, each issue addressed by an analysis team involves approximately forty experts, each of whom commits a total of 300 hours per year. Substantial resources are needed to conduct scientifically robust investigations and design interventions that truly mitigate risks. Thus

far, CAST has developed seventy safety projects. Forty-eight had been completed by February 2009, almost all without regulatory action by the FAA.

Background: Mistakes In Health Care

In a community teaching hospital on a snowy night, a fifty-eight-year-old man struggles for his life. His heart does not seem to be pumping sufficient blood to his organs. A procedure to verify this and guide treatment of the problem involves placing a catheter in the patient's neck vein, advancing it through the heart, and lodging it in the pulmonary artery.

A doctor in training, after consulting with an attending physician, decides to place the pulmonary artery catheter. Although it is generally known that inserting this catheter farther than 60 cm risks puncturing the patient's pulmonary artery (pulmonary arteries get smaller as they move away from the heart), the resident either does not know or forgets this detail. He advances the catheter 75 cm and unknowingly tears the pulmonary artery, and the patient starts coughing up blood. After several seconds of a frantically beating heart, the patient bleeds to death.

Health Care's Approach To Learning From Mistakes

The effectiveness and efficiency of CAST contrasts sharply with health care's approach to identifying and mitigating hazards. Health care organizations worldwide conduct relatively few in-depth investigations because resources are limited; they rely on local investigations and interventions that have a low probability of reducing future harm to patients; and they conduct few evaluations to determine the effectiveness of these interventions. Although local interventions are appropriate for some issues, they are inefficient and inadequate for many others. Methods are needed to identify hazards, their causes, and how widespread such hazards are; to prioritize hazards in health care; to determine the appropriate level of intervention; and to evaluate whether or not interventions reduced risks to patients. The tragic error depicted above is not rare, and a strong intervention to minimize the risk is easy to imagine but thus far impossible to achieve.

Patient-safety interventions can be classified by their capacity to prevent errors (Exhibit 1). An intervention with a high probability for reducing harm is a strong intervention, while one with a low probability for reducing harm is a weak intervention.⁸ In the pulmonary tear example, a weak intervention would "reeducate" doctors and nurses about the hazards of inserting a pulmonary artery catheter too far and would stress greater vigilance. A moderate intervention would place a removable bumper on the catheter at 60 cm, prompting a conscious decision by the clinician to exceed normal insertion parameters. A strong intervention would redesign the catheter to make insertion beyond 60 cm impossible. Strong interventions, also called forcing functions, remove any reliance on memory or vigilance and eliminate (or greatly reduce) the potential to make the mistake.

Although strong interventions are rare in health care, this should be the goal

EXHIBIT 1
Classifying Patient-Safety Interventions By Capacity To Prevent Error

Action, in order of ability to prevent harm (strongest to weakest)	Example: interventions to prevent pulmonary artery rupture from a pulmonary artery catheter
Eliminate or prevent mistake	Redesign the catheter to prevent insertion beyond 60 cm ^a
Make mistake visible	Place removable label on pulmonary catheter at 60 cm, flagging the risk of inserting beyond this point
Mitigate harm	Make smaller catheters so that the tear would be smaller
Educate	Develop a policy or educate staff about appropriate use of a pulmonary artery catheter

SOURCE: Authors' analysis.

^aThe evidence that 60 cm is the cutpoint for catheter insertion in all patients is uncertain. An unintended consequence of limiting a catheter to 60 cm is that it might not be long enough for some patients.

when designing interventions. Yet conducting robust evaluation and designing strong interventions requires resources that are often not available at the local level. For example, redesigning medical devices and products requires both human-factors and clinical expertise, as well as sufficient leverage in the form of market demand to persuade manufacturers to invest in such redesign. In addition, developing curricula to train health care workers to use the new devices and to work as a team, which may include simulation, could require thousands of hours of effort and sizable financial resources. Individual hospitals' efforts to reduce diagnostic, communication, and hand-off errors will inevitably result in under-resourced and often poor-quality interventions that have limited evaluation. The collective costs of this approach are substantial, while the benefits are minimal. It is neither efficient nor effective for individual hospitals to tackle these problems alone. For the most part, however, that is the current situation.

Yet health care has a number of notable successes. Perhaps the most heralded improvement was to eliminate the ability to connect oxygen gas tubing to nitrous oxide tubing. This safety strategy, prompted by higher-than-expected liability claims among anesthesiologists, involved detailed review of adverse events by anesthesiologists, anesthesia professional societies, engineers, and manufacturers. The strong solution was to redesign the shape of the yokes so the tubes carrying the two gases could not physically fit together.⁹ Another laudable example is the removal of concentrated potassium from patient care areas. Unfortunately, other examples of eliminating or preventing medical mistakes are rare. For example, every year an estimated 750,000 people suffer cardiac arrests in a hospital.¹⁰ Most hospital defibrillators require that a doctor or nurse review the patient's electrocardiogram, verify that the problem is "shockable," adjust the machine, and deliver the shock. Consequently, defibrillator operation errors are common.¹¹ Under time pressures, and often with limited hands-on experience, doctors often fumble to

set defibrillators accurately. What is needed is a yoke-type solution that redesigns the defibrillator controls to be intuitive to eliminate the potential for mistakes.¹² However, such a change has not yet been made.

Instead, mistakes such as these persist in health care institutions across the globe. Instead of insisting on redesigned defibrillators, well-intentioned managers reeducate staff. Because the latter intervention relies on fallible human memory and attention, it has a low probability of mitigating risk to future patients.¹³ Furthermore, the time required to reeducate all staff worldwide that use this equipment would be enormous. A more efficient and effective approach would involve collaborating with industry to redesign defibrillators (for example, with automated default settings) and other medical devices to make it impossible to commit this error. However, device redesign requires a coordinated effort among manufacturers, clinicians, human-factors engineers, and regulators. A forum for such collaboration has yet to be created.

Even when high-level standardized recommendations are made to mitigate risks, such as the Joint Commission standard for medication reconciliation to prevent medication errors or time-outs to prevent wrong-site surgery, these efforts have had limited success.¹⁴ Although there is no valid measure of incidence for these errors, the general consensus is that rates have not been reduced. Compared to commercial aviation, health care expends much less effort understanding systematic causes of errors and does virtually no pilot testing of interventions or robust evaluations to determine if efforts reduce the risk for patient harm before recommendations or standards for improvement are developed.

The need for robust evaluation likely varies inversely with the strength of the intervention. Given the complexity of health care and the potential for interventions to result in harm, an essential first step is to pilot-test interventions. Unintended consequences are the norm rather than the exception, and the effectiveness of the interventions is often opaque. When individual hospitals' efforts are compiled, the health care community invests sizable human and financial capital but reaps little benefit in terms of improved patient safety. Health care lacks a routine mechanism to develop and broadly implement strong interventions that mitigate risks to patients effectively and efficiently. CAST may provide a useful model.

Applying The CAST Model In Health Care

Conceptually, CAST could be emulated in health care. Public and private stakeholders in health care, including the Agency for Healthcare Research and Quality (AHRQ), the Food and Drug Administration (FDA), the Joint Commission, U.S. Pharmacopeia, the ECRI Institute, insurers, and health care provider organizations, could form a professional body and create a health care version of CAST, which we call the Public Private Partnership to Promote Patient Safety (P5S).

Although the details of how P5S would be governed, operated, and financed will require broad input, we offer some thoughts. AHRQ could provide leadership

and some support for this effort; AHRQ is interested in exploring this role. An executive board comprising representatives from the organizations mentioned above plus industry safety experts would oversee P5S. Confidentiality protections for hospital data should encourage participation. The confidentiality and privilege protections that would apply if providers submitted data to one of the new patient-safety organizations (PSOs) might be one approach. The confidentiality protections available for data collected as part of AHRQ-supported research projects might be another approach. The executive board could identify and prioritize important risks to patients that require industrywide solutions, then design, pilot-test, broadly implement, evaluate, and enforce strong interventions that greatly reduce these risks. To ensure that recommendations are implemented, P5S should forge links with federal regulators (the FDA and the Centers for Medicare and Medicaid Services, or CMS), the Joint Commission, the American Council for Graduate Medical Education, and the American Board of Medical Specialties, among others. Core staff would manage the daily operations of P5S and draw on the board and other experts to accomplish this work.

Until much-needed national or international error-reporting systems are implemented, P5S could use multiple sources of error data from specialized national databases (for example, the U.S. Pharmacopeia's MEDMARX) to inform and prioritize its work. Once PSOs are fully functioning and reporting patient-safety events to the network of AHRQ databases, P5S could draw on the reports that AHRQ is required by the Patient Safety and Quality Improvement Act to submit for inclusion in its annual *National Healthcare Quality Report*.

A conceptual model for mitigating risks at multiple levels of the health care industry could be used to identify the appropriate level for an intervention and when to involve P5S.¹⁵ For example, events that are unique to a unit, such as miscommunication, can be addressed at the unit level. Events limited to one hospital, such as lack of necessary supplies, can be addressed at the hospital level. Common events across hospitals, such as defibrillator operator errors, should be addressed at the industry level (country or global) and assigned to P5S.¹⁶ Some events will require multiple levels of intervention, and the science of determining the optimal level needs to mature. Because measuring risk reduction is less advanced and more challenging in health care than in aviation (medical errors affect a variety of important outcomes, while aviation errors focus on fatalities), we recommend that each level in the patient-safety community evaluate the effectiveness and efficiency of their risk-reduction efforts.

Barriers To Creating P5S

■ **Differing context.** Although P5S is conceptually appealing, several barriers must be overcome so that it can be created and used to reduce risks. One barrier is the context or systems in which hazards occur in aviation compared to health care. The aviation industry has well-defined settings (cockpit, taxi to take-off, ground

maintenance) and teams (cockpit crew, cabin crew, maintenance crew), with visible and concrete hazards and outcomes. The health care community is more complex, with an immeasurable number of clinical areas, therapies, technologies, protocols, and provider types, which makes identifying, measuring, and prioritizing hazards difficult. Although CAST has tangible evidence and data for its investigations, health care institutions and organizations are still struggling to clearly identify hazards and their causes, and to gain consensus for where to prioritize efforts.

There is uncertainty over how many patient-safety events will be amenable to the P5S approach. For now, P5S should narrow its focus to well-defined hazards that relate to technology use (for example, poorly designed equipment) before moving on to more complex widespread safety issues (for example, culture, diagnostic errors, or cognitive errors in surgery).¹⁷ Although P5S cannot conquer all patient-safety ills, particularly safety culture, it can address many problems.

■ **Participation of stakeholders.** A second barrier is the level of awareness and coordination among industry-level stakeholders. In aviation, the decision to redesign aircraft or mandate simulation training is backed by the government and by the fact that hundreds of fatalities will occur if one malfunctioning part or one inexperienced pilot causes a crash. Stakeholders recognize the consequences, and everyone plays on the same field. They have agreed to not compete on safety; safety is something they must guarantee for the flying public. The health care community is tangentially aware of deaths from hazards (such as pulmonary artery tears or errors in operating defibrillators), but one error equates to one death, not one hundred. Moreover, levels of commitment and knowledge of how to improve safety vary widely among health care organizations. Also, many in health care believe that providers should compete on safety. Consequently, the readiness of health care organizations to partner in P5S is uncertain. Still, many organizations recognize that their current efforts to improve safety are neither effective nor efficient.¹⁸

The track record for public-private partnerships in health care is fragile. The National Quality Forum (NQF) struggled financially and logistically from the wide focus of its efforts. The Leapfrog Group, based in the private sector, encountered substantial difficulty engaging senior federal-level participation. Nevertheless, CAST is effective, most likely because it focuses on identifying and mitigating specific hazards, it monitors progress toward reducing risks, and it has sufficient resources to conduct the required work. The P5S model has the same focus and can be viewed as a maturing of national patient-safety efforts by dividing safety into separate components. For example, efforts to translate evidence into practice require different methods than efforts to identify and mitigate hazards.¹⁹

■ **Finances.** A third barrier is financing P5S. Similar to CAST, stakeholders in health care will likely donate human and financial resources to conduct the work of P5S. Aviation comprises large organizations that have staff with the requisite technical expertise. As such, the financial burden of CAST on aviation companies is less than it would be in health care, where most organizations are small and technical

experts work for government agencies, ECRI, the Joint Commission, or universities that cannot afford to donate employees' time. If health care stakeholders cannot donate their time, external funding will be necessary for P5S to function. However, individual health care organizations are already spending sizable resources, although getting a limited return on their investment.

The federal government would be the best candidate to support P5S. Government agencies invest a penny in patient safety for every dollar they invest in basic and clinical research. To realize a return on taxpayers' investment in biomedical research to improve health, we need a more balanced investment across the entire "translation superhighway." Much like the human genome project, government could create and fund a patient-safety institute that oversees P5S and possibly includes a center to translate evidence into practice. Such an institute follows nicely with federal efforts to create a comparative effectiveness institute.²⁰

■ **Incentives for participation.** A final barrier is incentives for hospital participation. In aviation, even with many airlines suffering financial losses, the commitment to safety remains strong. The financial incentives for hospitals are substantial but may be opaque for some. Preventable complications hurt hospitals' bottom lines, and payer programs' intent to not pay for complications will strengthen this incentive.²¹ Hospitals are also starting to recognize the limited return on their ever-increasing investments in patient safety. The need for efficient and effective strategies to improve patient safety should encourage hospitals to participate.

HOSPITALS MAY FACE OTHER BARRIERS to participation. They need to recognize the shortcomings of their current approaches to mitigating risks. In addition, they must be humble enough to publicly discuss hazards within their institutions. This degree of transparency will encourage those reluctant to report events but may be difficult for some institutions. For example, the FAA sanctioned the Aviation Safety Action Program to resolve safety issues through corrective action, not punishment or discipline.

Although the barriers may be substantial, the time has come for a more systematic, focused, data-driven, disciplined, and cost-effective approach to reducing risks in health care. CAST provides an attractive model. Through a public-private partnership that includes key health care stakeholders, P5S could help lead the worldwide health care community to achieve higher levels of patient safety. It is neither efficient nor effective for health care providers to function alone.

Indeed, we have taken steps to realize this vision. An ad hoc group, to which the authors belong, has received a planning grant from the Robert Wood Johnson Foundation to further develop the governance, processes, and financing of P5S. Thus far, all stakeholders including AHRQ, the FDA, the Joint Commission, ECRI, and more than fifteen large health systems have agreed to participate. Given its oversight of PSOs and its interest in P5S, we believe that AHRQ should be the driving force in creating P5S.

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NOTES

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