Oral Testimony at

National Summit on Medical Errors and Patient Safety Research

Human Factors Research to Improve Patient Safety

I was asked on behalf of the Human Factors and Ergonomics Society to speak to you about the lessons from our past research. I am a recent past-president of the society, and I have been involved in R&D related to error and safety for 20 years beginning with nuclear power, then in studies human-machine teams in aerospace, and most recently as part of the patient safety movement.

Let me begin by quoting from an analysis of an accident:

> "although all of the necessary data was physically available, it was not operationally effective. No one could assemble the separate bits of data to see what was going on."

Human performance is puzzling--afterall, all of the data was available; why couldn't these people see what is obvious? Something must be wrong with them. They need re-mediation. Perhaps they need disciplinary action to get them to try harder in the future. Overall, we need to protect ourselves, our system, our organization from these erratic and unreliable other people.

The words I quoted have appeared in many accident reports from Three Mile Island in nuclear power to aviation crashes of highly automated aircraft. These words apply to tragedies in health care as well, and, unfortunately, we will see such words, and the puzzlement and frustration that follows, in reactions to future health care tragedies.

The puzzle of human performance is particularly frustrating because as stakeholders we also appreciate that success depends on expert human performance. In our moments of despair about this paradox along comes a tantalizing opportunity, what seems like an easy way out—computerize, automate, create a world without those other people who aren't as careful or as motivated as I am.

You are not the first industry to be puzzled and frustrated by the apparent irrationality of human performance. As the pediatrician said to the concerned parent during the flu season: "We've seen this before."

Who are we? You talk about us, though you don't know us or our results except in vague, distant ways. We are the various cognitive, behavioral and social sciences concerned with human performance at work—what is referred to as Human Factors.

How do we look past the surface puzzle of human performance? We use techniques to escape from hindsight and other biases to look behind the label human error. We use special techniques to study how people, distributed teams, and teams of people and computers solve problems.

What have we seen before? Behind the surface variability of specific practitioners in specific situations working with specific tools, we see common patterns in how people solve problems, how people collaborate, how people assign causes to explain failure, how people adapt to cope with complexity.

Where you are puzzled by erratic people; we see common patterns in problem solving and cooperative work. Where you see a new computer system to introduce or evaluate; we see common patterns in human-computer interaction, advisory systems, or computer supported cooperative work.

There are lawful relationships that govern the different aspects of human performance and, interestingly, our reactions to failure and the possibility of failure. These are not the natural laws of physiology, disease processes, and therapeutic interventions. They are the natural laws of cognitive, social and behavioral sciences.

In other words, the questions you are asking about patient safety and error need to be looked at from two perspectives in parallel. As John Senders has put it,

> "Human error in medicine, and the adverse events which may follow, are problems of psychology and engineering, not of medicine."

Our first recommendation is that the research program be built from the beginning as a substantive partnership between human performance specialties and health care specialties. This requires setting up mechanisms for an ongoing translation back and forth between the perspectives of human performance and the perspectives of health care.

For example, NASA's safety programs in aviation did not simply study aviation. Instead, NASA set up mechanisms to identify human performance issues that were important in aviation settings—a translation from aviation terms to human performance terms, for example, mental workload, flight crew team work, pilot-automation cooperation). It then sponsored and carried out work to better understand these human performance issues. Better understanding of the fundamental issues and regularities were then translated back into the aviation context in the form of new systems and programs to enhance that aspect of human performance (e.g., new tools to measure mental workload, new training programs to develop team work among flight crews, new designs of automated systems). To accomplish this, NASA had to invest to develop a cadre of human performance specialists who were sensitive to the unique demands of aviation and a cadre of aviation specialists who were sensitive to the theories that explain human performance.

While we already know a great deal about the conditions that promote success and reduce the potential for failure in systems at work, the results often deviate from conventional assumptions in startling ways. These results are very hard to understand on first exposure, yet they are the critical base for the research and other activities that will reduce the risk of injury as a result of care. Spend a couple of hours with the written testimony or other summaries of the lessons from Human Factors research. The written testimony, while brief, is packed with pointers to results that can save health care from re-inventing the wheel or worse, spinning its wheels as it tries to improve safety for patients.

But, research from Human Factors provides more than an efficiency advantage. Deep fallacies and oversimplifications about the natural laws that govern human performance at work are common across the blunt end of the health care system. These fallacies, or 'errors' about error, can lead us to squander the current window of opportunity, leaving health care systems with different latent failures ready to contribute to new tragedies. Let me quote from another accident analysis, one that points to the organizational contribution to accidents, the physicist's R. Feynman's short dissent from the Challenger accident report: "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled." Harsh words indeed, but they remind us of the character of high reliability organizations—they engage in a continuing process of questioning their own strategies and anticipating the changing potential for failure so they can adapt to avoid failure.

This morning I will translate the concerns about patient safety into a few of the relevant human performance questions, concepts and dynamic patterns. Each of these represents a broad area where partnerships should be established and fostered.

Research to Tame Complexity:
In the final analysis, the enemy of safety is complexity. Based on results from nuclear power in the 80's and from studies of flight crew-automation interaction in the 90's, we found some basic patterns that apply to health care today.

Inexorably, the pressure for increased capabilities and efficiency creates new demands on knowledge, judgment, and coordination, sometimes summarized as--*tighter coupling produces complexity*. We consistently find that introducing more powerful technology without also providing new levels and kinds of feedback about the situation and the activities of others contributes to failure, sometimes summarized as--*complexity without transparency produces error*. This leads to recommendations to find ways to avoid or eliminate excess complexity and particularly, importantly, *to balance increasing complexity with better feedback*. People, as individuals, groups, and organizations, *adapt to cope with complexity*. This leads to recommendations to support detection and recovery from incipient failure and to develop mechanisms to learn without accidents.

Transfer Methods for User Centered Design of Information Technology:
What we take for granted as the least common denominator in user centered design and testing of computer systems in other high risk industries seems to be far too rare in medical devices and computer systems. Computer displays, interfaces, and devices in health care exhibit "classic" human-computer interaction (HCI) deficiencies which can lead users to err. These design problems are well understood (e.g., they appear in our textbooks and popular writings) and the means to avoid these problems are readily available.

We are concerned that the calls for more use of integrated computerized information systems to reduce error could introduce new and predictable forms of error unless there is a significant investment in user-centered design. These methods are ready for transfer of technology types of projects.

Current examples where this knowledge could reduce misadministrations include computerized infusion devices and computerized devices for patient-managed care. Other areas where the human factors knowledge base is mature and can be transferred include the problem of alarm overload and high false alarm and the problem of mode errors in computerized devices.

In addition, new computer systems touted as safety advances embed automated computer cross checks. This is a well studied area of cognitive science, computer advisors and critiquing, with results on the difference between effective and ineffective critiquing relationships between people and computers. We recommend programs to use this knowledge base to set standards for new systems to catch potential medication misadministrations before they reach the patient.

Finally, the current and future levels of computerization in health care have created and will exacerbate a data overload problem. While the needed data will be available somewhere within multiple computer systems, finding the relevant set is a significant problem in human-computer cooperation. Because this is a generic problem, there is a great deal of R&D going on to address this problem in other industries which could be used to jump start solutions in health care.

Anticipate the Safety Implications of New Modes of Human-Human Cooperation

The skilled chess player does not choose a move based on the current board positions; the expert looks several moves ahead. Similarly, the research program on patient safety must look ahead at the changes affecting safety in health care. The research base on human performance can help you forecast challenges to safety and develop the programs to anticipate needs.

What is coming? The investment in new more integrated end-to-end computer based information systems and the availability of internet technology will completely change the nature of the collaborative relationships between health care practitioners and practitioners and patients.

We strongly recommend research now to consider how these changes can reduce or enhance safety. The changes underway can create new forms of failure and at the same time they are an opportunity for improving safety. High priority examples are tele-medicine and developing new ways to include patients as partners in their care.

The exploding field of computer supported cooperative work or CSCW should become a core area of expertise, research and development in health care. CSCW results already tell us that achieving high levels of coordination through the computer is a difficult challenge.

Master the Techniques for Studying Human Problem Solving at Work
Human factors has developed a repertoire of methods tailored to understand and evaluate human performance and human-computer interaction. These need to be transferred to health care.

In particular, one critical resource for these methods is simulation environments at different scopes and degrees of fidelity. Investing in simulation and learning to use this resource in studies of human performance needs to be significant part of the investment in research.

Another critical need is in the area of technology evaluation. Health care is far behind other industries in these techniques and how to integrate them into the innovation and development process.

Research has developed a variety of techniques to reduce hindsight bias. These are available to use and modify as necessary in health care research on safety. Methods to control for hindsight bias need to become a standard part of research on patient safety.

Create and Share Learning Tools
High reliability organizations promote learning activities that depend on open flow of information about the changing face of the potential for failure. These organizations encourage this information flow in multiple ways and act on this information to change without waiting for accidents to occur.

But in observations of health care, direct learning and improvement from experience with accidents and incidents has proven to be very limited and narrow. This appears to be partly because of the fear of blame and litigation. In addition, there are few organizational structures that promote learning about paths to failure.

An important area for new work is creating tools that promote learning and a culture of safety throughout health care organizations.

Blame is significant block to this information flow and learning process. To adopt a systems approach does not mean that health care should abandon accountability. Rather a systems approach means that we should study the effects of different systems of accountability, abandoning ones that degrade human decisions and adopting ones that enhance decisions in order to reduce risks to patients. This means we desperately need new answers to the question: How do we create a safe environment for learning about the potential for failure in a publicly accountable system of health care delivery? We recommend new multi-disciplinary research teams innovate and explore new models of accountability in a spirit of respect and cooperation for all stakeholders views.

Overall, past work in Human Factors reveals that for high reliability organizations, safety is a value not a commodity. From this emerges a simple standard emerges for judging success in research on error and safety. Research is successful to the degree that it helps recognize, anticipate, and defend against new paths to failure that arise as organizations and technology change, **before any patient is injured**.

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September 11, 2000