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Understanding better how clinicians work

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The paper by Chisholm et al¹ in this edition of *Annals* is a positive departure from typical medical research because it studies emergency physicians and their work *as it is happening*. Understanding work as performed, rather than as imagined by others, allows designers to develop systems that support the performance of that work, reduce error-producing conditions, and increase efficiency and job satisfaction; this approach is critical as we attempt to develop safer, more efficient and resilient systems. However, healthcare systems are often designed without this understanding. Thus, medical IT systems and devices, (e.g. electronic health records, computerized physician ordering systems, drug infusion pumps), are likely to be designed using inadequate or misleading information about how clinical work actually gets done. A classic example is barcode medication administration systems. Although barcode systems have the potential to dramatically reduce the occurrence of medication misadministration, there have been ineffective implementations because they were not designed to fit or support the actual work practices of the intended users. In one observational study of nurses, human factors researchers found that the increased time on task caused by the barcoding system collided with regulatory, workload, and staffing constraints such that nurses found it impossible to administer medications within the mandated timeframe, and consequently were forced to develop workarounds which put patients at risk.^{2,3}

While an important first step forward, the Chisholm et al. study only represents the tip of the iceberg in terms of ergonomic approaches to health care research. The purpose of this commentary is to introduce a broader set methods and approaches that could be brought to bear when studying clinical work in collaboration with human factors and ergonomics engineers.

Human factors engineering applies methods from engineering, psychology, biomechanics, and social science to improve the performance and reliability of human-technology systems. These methods support the design of systems that allow work to be more effective and efficient, while insuring safety and supporting resilience in response to failures and unexpected events. In particular, they use scientific data on human physical, perceptual, and cognitive capabilities and limitations to design better workplace environments, technologies, tasks, and work organizations. For example, human factors engineers use information about body sizes and biomechanics to design computer workstations that reduce the risk of repetitive stress injuries, or to design patient lifting aids that reduce injuries to staff. Human perceptual and cognitive characteristics (such as characteristics of memory and attention) are used to design displays and controls that are easily understood, draw attention to the right

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information, convey an understanding of how systems work, and help users recover from failures. Such designs can decrease the incidence of “use errors” caused by poor user interface design – events that are often labeled by the misleading term, “user error.”⁴ This term unfairly implies that the operator of the equipment is to blame, while in many circumstances the error is predictable and repeated, which suggests a shortcoming in interface design. For example, powering down a defibrillator when intending to deliver a shock, and failing to place a defibrillator in “sync” mode when attempting a synchronized cardioversion might both be considered to be attributable to the provider’s error, but studies have demonstrated that these missteps are common and are facilitated by the design of defibrillator displays and controls.^{5–7}

The work observation and time study methodology utilized by Chisholm et al is firmly rooted in the work measurement tradition of industrial and systems engineering, and is often used by human factors engineers as a part of a task analysis. Other available task analytic methods might have provided further insight, including hierarchical task analysis⁸, methods which focus on physical demands, and methods which focus on cognitive demands and cognitive work.^{9,10} One of the valid criticisms of the healthcare industry is our failure to partner with outside expertise in the safety domain. Unlike the aviation and nuclear industries, healthcare has been slow to reach out to safety science fields such as industrial engineering, systems engineering, resilience engineering, human factors engineering, and cognitive psychology.^{11,12} Methods and theories from these fields can add important insights to those from traditional time-motion methods such as described by Chisholm and colleagues. Interested readers can get a sense of the scope of engineering approaches to these problems by consulting the works listed in the references.^{10,13–28}

In particular, cognitive engineering methods give a comprehensive view of workload, by analyzing both the demands, constraints, and complexities associated with the work environment; and, the knowledge and strategies used by expert practitioners in order to cope with those demands (see Bisantz and Roth, 2008 for a comprehensive review).²¹ Results of these analyses are used to design system elements such as computer support (e.g. decision-support, automation, control interfaces), training programs, or team functions.²⁹ Design goals include supporting effective team communication; allowing individuals and teams to develop and maintain situation awareness and understanding of dynamic, often uncertain situations; and effectively managing workload across individuals and time. Many cognitive engineering methodologies use specialized interview techniques in order to identify specific components of work or expertise. For instance, the critical decision method uses multiple, structured interview sweeps which successively capture and refine an expert’s recollection of a critical past incident in order to identify components of expertise which support successful performance and decision-making in real world environments.¹⁵ Goal-directed task analysis focuses on practitioner goals and tasks in order to identify information elements necessary to support situation awareness.³⁰ Concept mapping is used to document expert knowledge and strategies, and observational methods are commonly used to understand components of the work domain and expertise.^{21,31}

Another method, cognitive work analysis (CWA) consists of a five-phased approach that iteratively focuses on: 1) the functions, constraints, priorities, processes, and physical structure of the work domain; 2) the tasks necessary to exert control or accomplish work within the domain; 3) the strategies used within those tasks; 4) the social and organizational aspects of the domain; and 5) the knowledge and skills necessary for successful performance within the work environment.^{10,13,25,32}

Researchers who approach these kinds of issues in the future would be well-served to develop substantive academic partnerships with scientists in these fields, to draw upon well-

established and time proven theories and methods for collection and analysis of these types of data. Human factors researchers often are as hungry for access to the healthcare “laboratory” as we in healthcare are (or should be) for their expertise. They can often be accessed through local universities (in departments such as Industrial Engineering, Computer Science, or Psychology) or through professional organizations (such as the Human Factors and Ergonomics Society (www.hfes.org), American Society of Safety Engineers, (www.asse.org), Association for Computing Machinery Special Interest Group on Computer-Human Interaction (www.sigchi.org), or IEEE section on Systems, Man, and Cybernetics (www.ieeesmc.org).

Chisholm and colleagues have made an important contribution by studying the work that people *actually* do, rather than relying on expert opinion, self reporting, focus groups, or secondary measures to describe the work that is *thought* to be done (or worse, work that is thought *ought* to be done). We commend them for their work, and for pointing us towards new ways of examining clinical work. However, we point out that well-developed, robust methods exist that might have provided a higher level of insight into more aspects of work. We encourage researchers to broaden their methods by pursuing collaborations with experts outside healthcare; gaining an in-depth understanding of the nature of clinical work will facilitate better design of systems and system components for improved safety, efficiency, and reliability.

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References

1. Chisholm CD, Weaver CS, Whenmouth LF, Giles B. An Ergonomic Characterization of ED Physician Activities in Academic and Community Settings. *Ann Emerg Med*. 2011; XXX(X)
2. Patterson ES, Rogers M, Chapman RJ, Render ML. Compliance with intended use of bar code medication administration in acute and long-term care: An observational study. *Human Factors*. 2006; 48(1):15–22. [PubMed: 16696253]
3. Patterson ES, Cook RI, Render ML. Improving patient safety by identifying side effects from introducing bar coding in medication administration. *Journal of the American Medical Informatics Association*. 2002; 9:540–553. [PubMed: 12223506]
4. Norman, D. *The Design of Everyday Things*. New York: Basic Books; 1988.
5. Fairbanks RJ, Caplan SH, Bishop PA, Marks AM, Shah MN. Usability study of two common defibrillators reveals hazards. *Annals of Emergency Medicine* Oct. 2007; 50(4):424–432.
6. Fairbanks RJ, Wears RL. Hazards With Medical Devices: The Role of Design. *Ann Emerg Med*. Nov; 2008 52(5):519–521. [PubMed: 18722693]
7. Hoyer CS, Christensen EF, Eika B. Adverse design of defibrillators: turning off the machine when trying to shock. *Annals of Emergency Medicine* Nov. 2008; 52(5):512–514.
8. Annett, J. Hierarchical Task Analysis. In: Hollnagel, E., editor. *Handbook of Cognitive Task Design*. Mahwah, NJ: Lawrence Erlbaum Associates; 2003. p. 17-35.
9. Bisantz, AM.; Burns, CM. *Applications of Cognitive Work Analysis*. Boca Raton, FL: CRC Press; 2008.
10. Vicente, KJ. *Cognitive Work Analysis*. Mahwah, NJ: Lawrence Erlbaum Associates; 1999.
11. Nemeth CP, Cook RI, Wears RL. Studying the technical work of emergency care. *Annals of Emergency Medicine* Oct. 2007; 50(4):384–386.
12. Wears RL. A different approach to safety in emergency medicine. *Annals of Emergency Medicine*. 2003; 42(3):334–336. [PubMed: 12944884]
13. Rasmussen, J.; Pejtersen, AM.; Goodstein, LP. *Cognitive Systems Engineering*. New York: Wiley and Sons; 1994.

14. Klein, GA.; Orasanu, J.; Calderwood, R.; Zsombok, CE., editors. *Decision Making in Action: Models and Methods*. Norwood, NJ: Ablex Publishing Corporation; 1993.
15. Crandall, B.; Klein, GA.; Hoffman, RR. *Working Minds: A Practitioner's Guide to Cognitive Task Analysis*. Cambridge, MA: The MIT Press; 2006.
16. Hoffman R, Crandall B, Shadbolt N. Use of the critical decision method to elicit expert knowledge: A case study in the methodology of cognitive task analysis. *Human Factors*. 1998; 40(2):254– 276.
17. Hollnagel, E.; Woods, DD.; Levenson, N. *Resilience Engineering: Concepts and Precepts*. Aldershot, UK: Ashgate; 2006.
18. Hollnagel, E.; Woods, DD. *Joint cognitive systems: Foundations of cognitive systems engineering*. Boca Raton, FL: Taylor & Francis; 2005.
19. Woods DD, Roth EM. Cognitive Engineering: Human Problem Solving with Tools. *Human Factors*. 1988; 30(4):415– 430.
20. Roth EM. Uncovering the Requirements of Cognitive Work. *Human Factors*. 2008; 50(3):475– 480. [PubMed: 18689056]
21. Bisantz, AM.; Roth, EM. Analysis of cognitive work. In: Boehm-Davis, DA., editor. *Reviews of Human Factors and Ergonomics*. Vol. 3. Santa Monica, CA: Human Factors and Ergonomics Society; 2008. p. 1-43.
22. Bisantz AM. Cognitive engineering applications in health care. *The Bridge*. 2008 Winter;:39–47.
23. Bisantz AM, Roth EM, Brickman B, Gosbee L, Hettinger L, McKinney J. Integrating cognitive analyses in a large scale system design process. *International Journal of Human Computer Studies*. 2003; 58:177– 206.
24. Roth, EM.; Patterson, ES.; Mumaw, RJ. Cognitive Engineering: Issues in User-centered System Design. In: Marciniak, JJ., editor. *Encyclopedia of Software Engineering*. 2. New York: Wiley Interscience, John Wiley and Sons; 2002. p. 163-179.
25. Burns, CM.; Hajdukiewicz, J. *Ecological Interface Design*. Boca Raton, FL: CRC Press; 2004.
26. Elm, WC.; Potter, SS.; Gualtieri, JW.; Easter, JR.; Roth, EM. Applied Cognitive Work Analysis: A Pragmatic Methodology for Designing Revolutionary Cognitive Affordances. In: Hollnagel, E., editor. *Handbook of Cognitive Task Design*. Mahwah, NJ: Lawrence Erlbaum Associates; 2003. p. 357-382.
27. Roth EM, Christian CK, Gustafson ML, et al. Using field observations as a tool for discovery: Analyzing cognitive and collaborative demands in the operating room. *Cognition Technology and Work*. 2004; 6:148–157.
28. Woods, DD.; Dekker, SWA.; Cook, RI.; Johannesen, L.; Sarter, NB. *Behind Human Error*. Aldershot, UK: Ashgate; 2010.
29. Naikar N. Beyond interface design: Further applications of cognitive work analysis. *International Journal of Industrial Ergonomics*. 2006; 36(5):423–438.
30. Endsley, M.; Bolte, B.; Jones, D. *Designing for Situation Awareness*. New York: Taylor & Francis; 2003.
31. Bisantz, AM.; Drury, CG. Applications of archival and observational data. In: Wilson, JR.; Corlett, N., editors. *Evaluation of Human Work*. 3. Boca Raton: Taylor and Francis; 2005. p. 61-82.
32. Burns, CM.; Enomoto, Y.; Momtahan, K. A cognitive work analysis of cardiac care nurses performing teletriage. In: Bisantz, AM.; Burns, CM., editors. *Advances in Cognitive Work Analysis*. Boca Raton, FL: CRC Press; 2008.