Use Error Hazards from a Popular Emergency Department Information System

30-MINUTE PRESENTATION SUMMARY

Number of Presenters:	One
Topic Category:	[ ] Usability perspectives [ ] New approaches, Methods or Technologies [ ] Methods & Skills [ ] Accessibility & Internationalization, [ ] Managing User Experience [x] Case Studies
Intended Audience:	[x] Everyone [ ] Individuals New to Usability [ ] Experienced Practitioners [ ] Technical/Professional Leadership
Special Audio Visual Requirements:	A computer projector, lectern, and microphone will be provided for each presentation session. List any additional AV or other special requests. Presenters are expected to pay for any additional equipment needed.

ABSTRACT:

Health IT systems are not subject to FDA requirements for interface design standards. ED Information Systems (EDIS) provide support for all aspects of patient care in the emergency department. Results are presented from a usability/heuristic evaluation which reveals hazards in a popular commercially-available EDIS system.

GOALS FOR THE SESSION:

Attendees at this session will:

- Understand the functioning of a hospital emergency department information system (EDIS) and its GUI as an example of an interface that must support a critically collaborative real-time work situation.
- See examples of interface design interactions which have a high likelihood of leading to particularly hazardous use errors and adverse outcomes such as delayed care or harm to emergency department patients.
- Learn of design solutions which could potentially decrease the rate of use error in EDIS and in similar collaborative systems with complex user interfaces

HANDOUTS OR OTHER SESSION MATERIAL

The PowerPoint presentation and any supplemental material will be included in the conference proceedings.

PREVIOUS PUBLICATION OR USE OF THIS MATERIAL

No previous presentation

REFERENCES

This work builds on previous work of our own research group. in the areas of

- User research of pre-digital emergency department information systems
- Laboratory testing of defibrillator user interfaces
- Analysis of user interface contribution to an adverse emergency department event

(specific references are provided throughout text and focus on our current work)

YOUR BACKGROUND IN THIS MATERIAL

The presenter is a human factors engineer (MS, Virginia Tech) and a physician/medical school faculty member (specialized in emergency medicine), who for 5 years has teamed up with usability professionals, patient safety experts, and human factors engineering professors to study human factors issues in the emergency department (ED) environment. For the past three years we have studied the transition from paper-based records and manual "whiteboard" ED patient tracking systems to electronic, computer based information systems.[1] The team has also studied the usability of medical devices, and created simulation models for EDIS systems.[2,3,4,5,6,7,8] This has lead them to work on the current study as a team. This proposal is to present a heuristic evaluation of a commercially available EDIS system.

SESSION SCHEDULE WITH TIME ALLOCATION

Number of Minutes	Topic or Event
7	Familiarization with the ED environment with a specific focus on the integration and function of EDIS
7	Description of the heuristic study ✓ Objectives ✓ Methods ✓ results
7	Implications of these results and proposed solutions
9	Question & answer session (audience participation)

DETAILED DESCRIPTION OF PRESENTATION CONTENT

1. Introduction and Background

Since the beginning of this decade's patient safety movement, there has been great recognition of the value of bringing outside expertise into the medical field, such as safety engineering and safety science disciplines which have created highly reliable safety environments in other complex, high-risk industries such as aviation, chemical production, and the nuclear industry.

Traditionally in medicine when an adverse event occurs in medicine the natural reaction has been to assign fault to a person. The systems approach to reducing adverse events indicates that latent factors exist and can either permit hazards to cause adverse events or fail to protect patients from the effects of hazards. Safety science experts in other high-risk complex industries have designed highly reliable systems by focusing less on human error, which cannot be eliminated, and more on latent factors in the system which are capable of facilitating or averting adverse events. Shortcomings in medical device and health information technology (HIT) design serve as examples of latent errors which can lead to adverse events. These contributing factors usually go unnoticed because the most obviously apparent "fault" lies with the nurse, paramedic, or physician who was interacting with the system (the "sharp end" user).

Published standards for the design of medical devices specify a need for usability testing, but there is no requirement to make results available to the consumer.[9,10] Furthermore, the FDA has

determined that these requirements do not apply to HIT systems, such as ED Information Systems. A higher level of awareness of the existence of usability test data might compel emergency medicine, EMS, and hospital leadership to request usability testing results when considering a new product. This should in turn drive change in the industry, which presently has no pressure from the consumer to produce usability testing results.

Despite the fact that usability testing is a standard practice in other high-consequence industries, only a few examples exist in the medical literature. Lin et al. report using simulation to compare the standard user-interface on a commercially available patient-controlled analgesia pump with a new interface that was designed using human factors principles.[11] Drug concentration errors occurred with the standard interface despite the fact that users were nurses with at least 5 years' experience with the device, while no errors occurred with the revised design following HFE principles.

One study applied usability testing methods to optimize a decision support system in the university hospital computer provider order entry system.[3] Another revealed several usability problems with common defibrillators, including a high error rate in synchronized cardioversion mode that could be attributed to interface design.[2] These cases demonstrate two critical points: First, the commercial medical device and HIT industry do not consistently deliver products with user-interface designs that are optimized for patient safety, and second, analyses of existing devices and HIT systems have the potential to both reveal latent hazards (design shortcomings) and to propose and test solutions.

There is a critical need for Human Factors Engineering approaches and methodologies such as usability testing in emergency medicine. There is a current rapid expansion of healthcare information technology (HIT) systems in all medical specialties, including emergency medicine. Emergency Department Information Systems (EDIS) are HIT applications which are intended to be tailored to the operations and the documentation needs of the emergency department. But these applications sometimes introduce new potential for error, as was described in one study by members of our research team.[12] Although it is clear that complete saturation of EDIS systems into the nation's EDs is inevitable, there is no standard that requires the engineering of these systems to integrate usability and human factors engineering (HFE) concepts. Several recent studies in the medical literature have shown the danger of such latent hazards, including a well-publicized study that showed an increase in adverse events after implementation of a computerized physician order entry system.[13] Another reason to have intuitive designs is that extensive training in the use of EDIS is not practical given the influx of new personnel and temporary staff who rotate in and out of many EDs, such as off-service residents or traveling nurses. Lack of familiarity and inconsistency between systems can lead to use error. As EDIS and other HIT systems become increasingly complex and more integrated into the nation's EDs, the need for interface design that has been optimized for patient safety will become increasingly critical.

2. Description of the problem or subject of presentation

The presenters have previously studied the impact of the transition to this EDIS system as part of a grant funded study, and preliminary qualitative data revealed that the user-interface design of this system is not ideally suited to the ED environment, and physicians and nurses have expressed concern that there may be potential for these problems to lead to adverse events, or unintended hazards to patients. As a result, a major study is underway to conduct heuristic evaluation and usability studies on this product to identify user-interface design characteristics that have the potential to cause adverse events and therefore impact patient safety in emergency medicine. The specific aims of this program to:

1. Determine whether the human interface of a popular mass-marketed EDIS system contains design characteristics which violate known and accepted user-interface design principles and standards. This aim will be accomplished using heuristics. The expert reviewers will include two experienced usability scientists without medical training, and two emergency physicians backgrounds in human factors engineering.
2. Conduct usability testing research to evaluate the user-interface performance of the EDIS system, in order to determine the potential impact that the design standard violations discovered in aim #1 can have. The rate of use error will be determined for each task, and use error which is attributable to violations of existing user-interface design standards will be identified (since these can be considered avoidable with improved design).
3. Use the results of the first two aims to develop design recommendations which can be applied to improve existing EDIS systems and to optimize new EDIS systems under development.

The aim of this presentation is to report results from Aim #1, the heuristic evaluation, as a way to educate attendees about complex, critical user interfaces.

3. Methods.
A heuristic evaluation method is undertaken, using the following list to evaluate for successes and violations, (adapted from previous studies in the literature)

1. *Internal Consistency*. Similar tasks within the system should be presented and performed in similar ways and should use the same terminology.
2. *External Consistency.* Method of operation, terminology, and presentation of information is compatible with users' expectations based on their knowledge of other types of products/systems and the "outside world".
3. *Visibility*. System status and changes should be informed using appropriate feedback and display of information.
4. *Match*. A match should exist between user expectations of the system and actual system characteristics.
5. *Minimalism.* Extraneous information is a distraction and should be minimized.
6. *Memory.* Users should not be required to memorize much information to carry out tasks.
7. *Feedback*. Informative feedback. Users should be given prompt and informative feedback about their actions.
8. *Flexibility*. The system should allow flexibility of creating customization and shortcuts for advanced users
9. *Message*. Error messages should be informative enough such that users can understand the nature of errors, learn from errors, and recover from errors.
10. *Error.* Prevent errors; The interface should be designed to maximize prevention of errors from happening in the first place (forcing functions, etc).
11. *Closure*. Each task has a clear beginning and an end and task completion is communicated to users.
12. *Undo.* Actions are reversible so that users are able to recover from errors (this also encourages exploratory learning).
13. *Language.* The language should be always presented in a form understandable by the intended users.
14. *Control.* Maintain user control, and do not provide the impression that the users are controlled by the system.
15. *Documentation*. Always provide an option for help and documentation when needed.

Each usability expert will evaluate the user interface of the EDIS system during observations and using hands-on time with a skilled user of the system in the natural environment (while being used for normal function in the ED), with a focus on pre-defined tasks which are common to the index user (for example, observe an emergency physician writing electronic prescriptions). Using the 15-item list of interface design principles, each of them will generate a separate list of heuristic violations. These three lists will then be combined, and redundant items merged. The reviewers will then independently assign severity codes to each item using the following scale of likelihood to cause errors:

4 = Very *High;* 3 = *High;* 2 = *Moderate;* 1 = *Slight;* 0 = *None*

Consideration will be given to the following three factors when determining usage severity:

- the proportion of users who might experience such a violation,
- the impact this violation will have on their error rate
- whether the violation is likely to impact users repeatedly, or only the first time they encountered it.

Note that the ease or difficulty of fixing a problem will not be considered in the severity rating.

Patient safety impact score. Each of these violations will be given a score based on the reviewers' subjective assessment of the potential for impact on the patient as follows. (An **adverse event** will be defined as an injury caused by medical management rather than the underlying condition of the patient, whether from an act or omission, preventable or non-preventable).

3= is likely to cause adverse event

2= has appreciable potential to cause an adverse event
1= unlikely to cause an adverse event
0= impossible to cause an adverse event

4. **Results and Conclusions**

At the time of this submission, the heuristic evaluation is underway but three more sessions are scheduled, so full data are not available for analysis and therefore cannot be reported here. The data will be analyzed by mid-winter, and will certainly be ready by the March slide deadline. We hope that the committee will consider accepting this presentation pending results.

Analysis will include data plotted on a grid whose axis are Usage Severity and Safety Impact. This gives the context for design solutions – i.e., emphasis is on design deficiencies having high usage severity and high safety impact.

5. **References**

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[2] 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. Associated editorial: Karsh and Scanlon, Oct 2007; 50(4): 433-435.

[3] Fairbanks RJ, *Cardiac Monitor Interface Design Facilitates Patient Death.* In: Alvarado CJ, Carayon P, Fairbanks RJ, Karsh BT, Perry SJ, Sharit J, Wiegmann DA. *Macroergonomics and Patient Safety in Health Care,* Proceedings of the Human Factors and Ergonomics Society 51st Annual Meeting, Human Factors and Ergonomics Society, October 2007.

[4] Fairbanks RJ, Caplan S, Panzer RJ. *Integrating Usability Into Development Of A Clinical Decision Support System.* Proceedings of HCI-International 2005, Mira Digital Publishing (ISBN 0-8058-5807-5). July 2005; Las Vegas, Nevada.

[5] Pennathur P, Bisantz AM, Fairbanks RJ, Perry SP, Wears RL, Zwemer FL. *Assessing the Impact of Computerization on Work Practice: Information Technology in Emergency Departments,* Proceedings of the Human Factors and Ergonomics Society 51st Annual Meeting, Human Factors and Ergonomics Society, October 2007.

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[11] Lin L, Vicente KJ, Doyle DJ. Patient Safety, Potential Adverse Drug Events, and Medical Device Design: A Human Factors Engineering Approach. *Journal of Biomedical Informatics.* August 2001;34(4):274-284.

[12] Wears RL, Perry SJ, Shapiro MJ, et al. A Comparison of Manual and Electronic Status Boards in The Emergency Department: What's Gained and What's Lost? *Proceedings of the Human Factors and Ergonomics Society 47th Annual Meeting Denver, CO: Human Factors and Ergonomics Society.* 2003:1415-1419.

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