Title

Design and analysis of a Web-based guideline tutorial system that emphasizes clinical trial evidence.

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Design and Analysis of a Web-based Guideline Tutorial System that Emphasizes Clinical Trial Evidence

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ABSTRACT

Objective. *To describe a Web-based guideline tutorial system and evaluate its features.*

Methods. *A Web-based tutorial system called SAGE (Self-study Acceleration with Graphic Evidence) was constructed to teach knowledge important for care after myocardial infarction. SAGE features a pretest, followed by an overview that coordinates studying resources for a set of learning objectives. Resources include pretest answers, guideline passages, and graphical presentations of clinical trial results. Data on the use of SAGE was obtained from 79 residents participating in a larger trial. Linear regression was used to correlate the amount learned with resource-use, and resource-use with user characteristics.*

Results. *On average, users accessed less than half of the guideline passages and very little of the graphic evidence. Greater use of guideline passages was correlated with greater immediate learning, but use of graphic evidence was not.*

Conclusions. *Further research is needed to motivate more thorough self-study and to integrate clinical trial evidence with guideline-based education.*

INTRODUCTION

Guidelines are written to influence physicians,[1] and physicians report that they do read from guidelines to update their knowledge.[2] Physicians may fail to learn from these efforts, however.[3] Significant efforts in medical informatics have focused on the automated implementation of guidelines,[4] but many guideline systems will likely need to interface with physicians who can understand and trust their recommendations.[5]

Computer-assisted instruction (CAI) may help to improve learning from guidelines. In theory, CAI can enhance learning by tailoring material to a learners' individual needs, and by providing simulations that demonstrate quantitative relationships among causes and effects.[6] In medicine, many CAI systems have been organized around patient simulations,[7-10] which may enhance learning by providing a motivating, realistic scenario, but which may also fail in their realism,[11] and which might be time-inefficient.[12]

We constructed a Web-based instruction system called SAGE (Self-study Acceleration with Graphic Evidence), which combines tutorial and quantitative simulation features. We then conducted a randomized, controlled trial to compare the educational outcomes from SAGE with the outcomes from self-study using content-equivalent printed materials. The main results of this trial are reported separately.[13] This paper reports a more detailed exploration of the design features of SAGE.

METHODS

System Design

Two guidelines on the care of acute myocardial infarction (AMI)[14,15] form the core teaching materials for SAGE. We wrote 20 "cognitive" learning objectives, covering knowledge from one or both guidelines important for providing follow-up care after AMI. We also wrote multiple-choice questions that evaluate the achievement of these objectives, and we pilot tested and revised the questions using an email quiz administration system.[16] Final questions were arranged into a pretest and a posttest each with one question per learning objective, and each having approximately equal difficulty. SAGE was designed to use pretest results as a central stimulus to study content for each learning objective. Since each learning objective was evaluated by a single pretest item, however, there was a significant chance that by choosing the correct answer accidentally learners could lose the pretest stimulus for any given objective. To provide an additional means for learners to identify topics that they need to learn more about, each test question was given an additional response option that said "I would like to review available evidence or recommendations on this topic."

Users began their interaction with SAGE by logging on and copying their pretest results into the system. **Figure 1** depicts the sequence of interactions that follow. Users are taken to the "main tutorial page" (**A**), which is intended to organize their studying for the entire learning activity. The left side of this page provides an overview of the learning objectives, and the right side of the page initially shows users their overall pretest scores. Users can then click on any

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A. The main tutorial page shows an overview of the learning objectives in the left panel, with a if the user answered the relevant pretest question correctly or an **X** if the user answered incorrectly. A **?** indicates that the user had flagged the pretest question for further review. Clicking on a learning objective displays its pretest question in the right panel, with the correct answer shown in bold green font and the user's response marked with a (if correct), or an **X**. Below each question, one or more hyperlinks led to the relevant guideline passages.

B. The guideline browser opens displaying the complete guideline document, with the exact passage relevant to the selected learning objective highlighted in green font. The guideline's table of contents, in the left panel, can be used to browse the broader context of the passage. Where the guidelines make reference to a landmark randomized trial, users can select an "evidence link" (the scales icon), opening the randomized trial viewer. If other passages in the same guideline apply to the learning objective additional hyperlinks are embedded in the text (not shown).

C. The randomized trial viewer displays a standard graphical view of the results from any randomized trial in the SAGE database. Inclusion and exclusion criteria for each trial are listed at the top. Below, outcomes from the trial are displayed graphically. A bar graph shows the absolute outcomes reported for each arm of the trial. An adjacent graph shows the associated relative risk estimates, with lines representing their 95% confidence intervals.

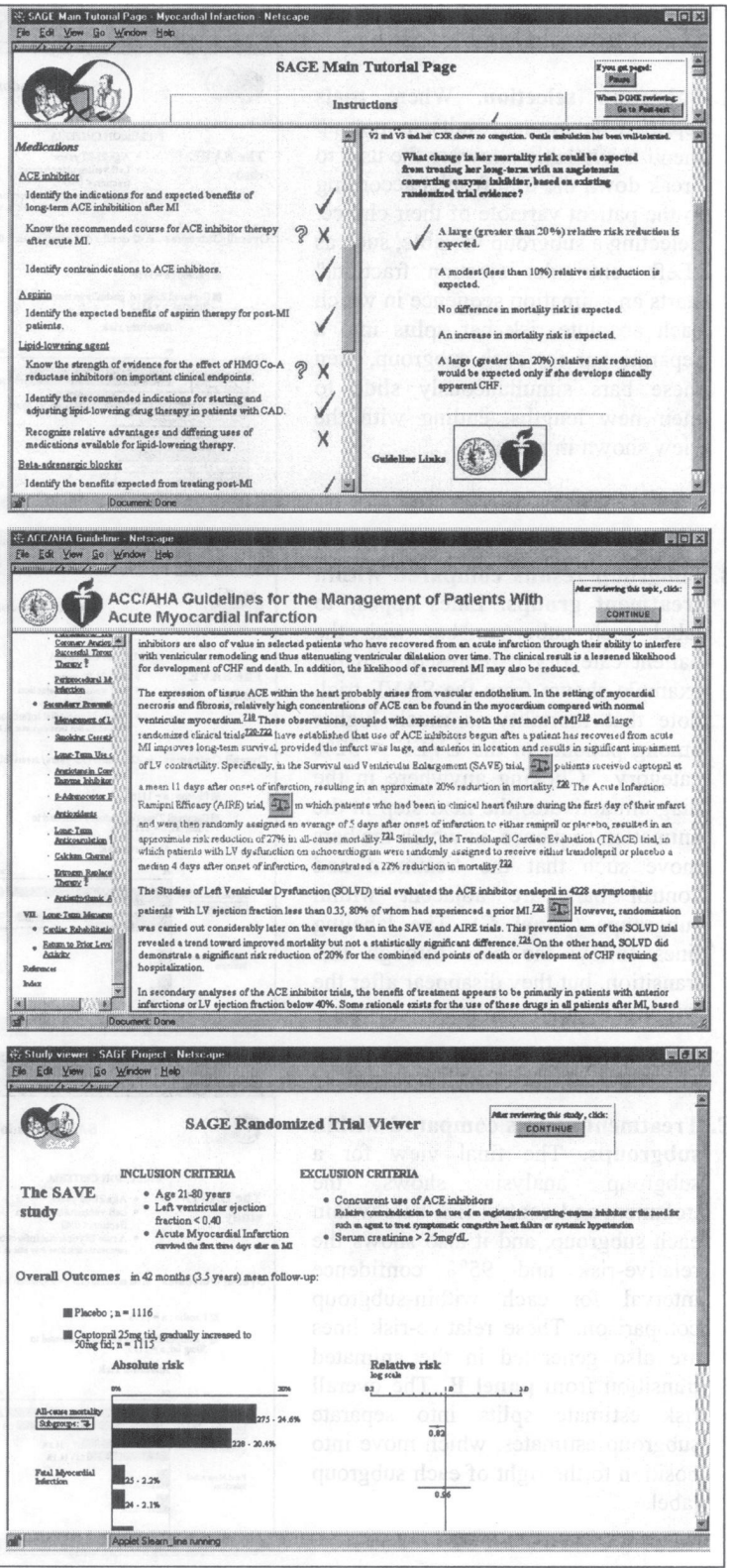

Figure 1. The SAGE user interface, showing the sequence of learning resources for one learning objective.

A. Subgroup selection. Where trials reported subgroup results, a pop-up menu is available allowing the user to break down the trial results according to the patient variable of their choice. Selecting a subgroup variable, such as "Left ventricular ejection fraction," starts an animation sequence in which each absolute risk bar splits into a separate bar for each subgroup, then these bars simultaneously slide to their new lengths, ending with the view shown in **panel B**.

B. Subgroup results compared within treatment groups. Lines appear to label each subgroup bar with the patient category it represents. In the example shown from the SAVE trial, note that mortality is much higher among patients in the LVEF <=32% category. Clicking anywhere in the diagram activates the next step in the animation sequence, in which the bars move such that the treatment and control bars are adjacent within subgroups (**panel C**). The labeling lines follow the bars through this transition, but they disappear after the within-subgroup results are adjacent.

C. Treatment results compared within subgroups. The final view for a subgroup analysis shows the treatment and control risk bars within each subgroup, and it also shows the relative-risk and 95% confidence interval for each within-subgroup comparison. These relative-risk lines are also generated in the animated transition from **panel B**. The overall risk estimate splits into separate subgroup estimates, which move into position to the right of each subgroup label.

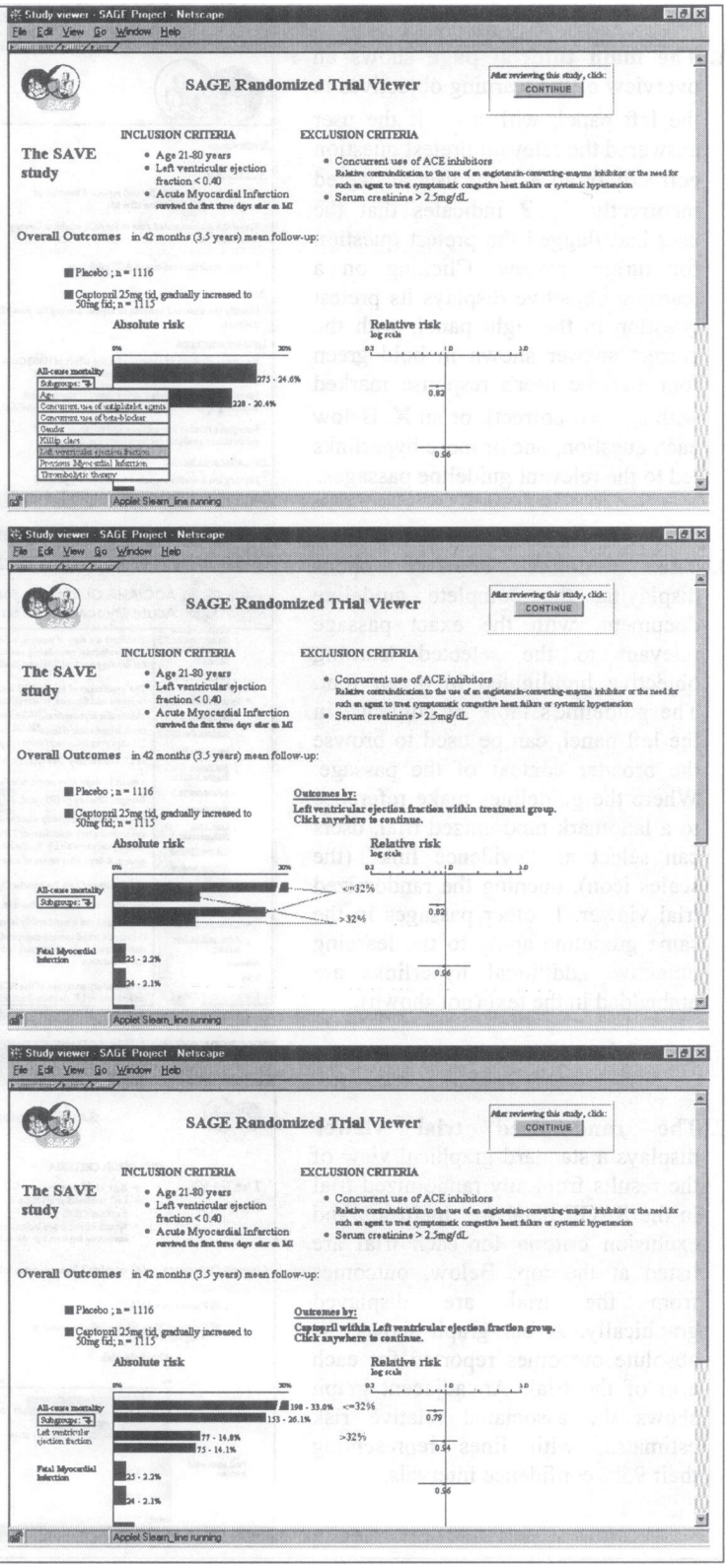

Figure 2. Graphical evidence animation in the SAGE randomized trial viewer. The sequence continues Figure 1.

learning objective to begin studying the resources relevant to that objective. The first resource available is the answer to the pretest question for the given learning objective. One or more guideline icons then provide access to the next level of learning resource, the guideline passage (**B**). For the final level, "graphic evidence" icons embedded within the guideline text provide access to the randomized trial viewer (**C**). **Figure 2** shows how animation is used to present subgroup analyses from randomized trials.

SAGE software was written using Server-side JavaScript (Netscape, Mountain View, Calif.), and an Oracle7 database (Oracle, Belmont, Calif.) running on an UltraSPARC2 workstation (Sun Microsystems, Mountain View, Calif.) The database was used to store both the data collected from subjects and the knowledge that drove the application, including the learning objectives, guideline information, and data abstracted from landmark clinical trials. Graphical evidence animations were presented by a Java applet that retrieves numeric trial results from the database and renders the graphics dynamically.

Evaluation

We recruited internal medicine and family practice residents at 4 universities. Participants attended a single, proctored self-study session that began with administration of the pretest on paper. Half of participants were randomly assigned to study from SAGE (n=83), with the other half assigned to a control self-study arm. Subjects were asked to study until they felt they had met all of the learning objectives. After studying, all subjects immediately completed the posttest. Tests were scored with one point for each correct answer, for a possible range from 0–20. Participant demographics were obtained from an enrollment form. SAGE automatically tracked and counted each subject's use of resources. Analyses reported below correlate use of resources with the amount learned and with subject characteristics using linear regression.

RESULTS

Resource-use and posttest data were complete for 79 of the original SAGE-group participants. Their mean age was 29, 39% were female, 29% were in family medicine programs, and 35%, 33%, and 32% were first, second, and third-year residents, respectively. Thirteen percent reported having used the Web less than 5 times ever, and 85% reported having a computer at home. Mean pretest scores were 9.7 (SD 2.8), and mean posttest scores were 14 (SD 2.3).

Users spent a mean of 29 minutes studying from SAGE (SD 12). **Figure 3** shows that different subjects used the available resources to different extents. Most subjects viewed 19 or all 20 of the question answers, but 3 subjects viewed less than 8. The mean number of guideline passages viewed was 12 out of 28 possible, and the mean number of randomized trials viewed was 1 out of 12, with a tail extending to one person who viewed 8 trials.

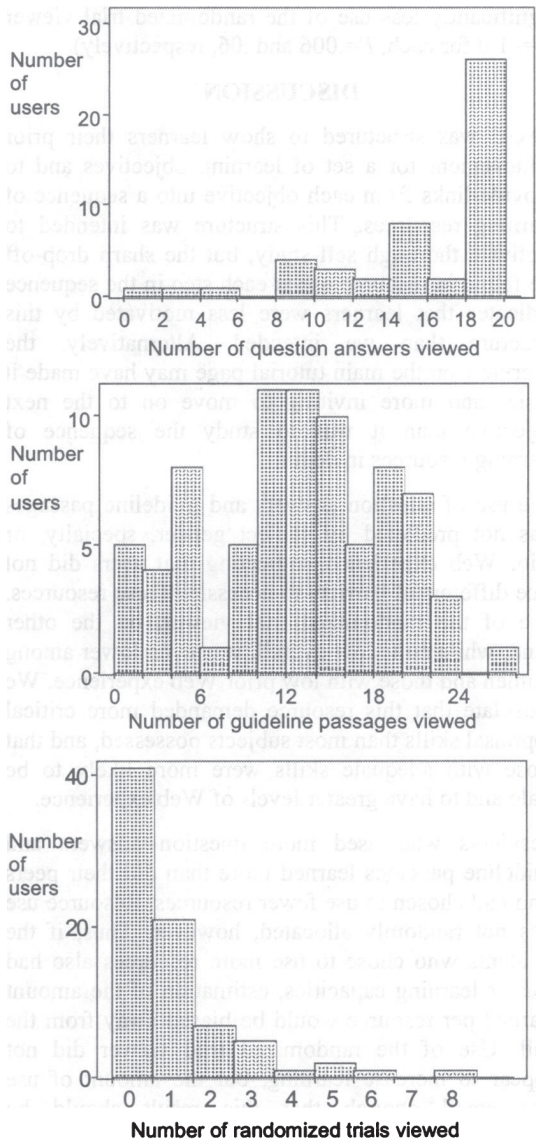

Figure 3. Distribution of resource-use among subjects. A resource was counted as used by the subject if the subject accessed one or more times.

In a linear regression model for posttest scores, with adjustment for pretest scores, both the number of question answers viewed and the number of guideline passages viewed were significantly associated with higher posttest scores (β=.12 per answer viewed, P=.03; β=.13 per passage viewed, P=.003; R^2=.32).

Viewing graphic evidence, on the other hand, was not associated with higher posttest scores (P=.93). In regression models predicting the use of SAGE features, no user characteristics were correlated with the number of question answers or guideline passages viewed. Female gender and low prior Web experience, however, were correlated with significantly less use of the randomized trial viewer (β=–1.0 for each, P=.006 and .06, respectively).

DISCUSSION

SAGE was structured to show learners their prior achievement for a set of learning objectives and to provide links from each objective into a sequence of learning resources. This structure was intended to motivate thorough self-study, but the sharp drop-off we found in resource use at each step in the sequence indicates that learners were less motivated by this structure than we intended. Alternatively, the overview on the main tutorial page may have made it easier and more inviting to move on to the next objective than it was to study the sequence of learning resources in depth.

The use of question answers and guideline passages was not predicted by subject gender, specialty, or prior Web experience, indicating that users did not face differential barriers to accessing these resources. Use of the randomized trial viewer, on the other hand, while quite low overall, was even lower among women and those with low prior Web experience. We speculate that this resource demanded more critical appraisal skills than most subjects possessed, and that those with adequate skills were more likely to be male and to have greater levels of Web experience.

Residents who used more question answers and guideline passages learned more than did their peers who had chosen to use fewer resources. Resource use was not randomly allocated, however. Thus, if the residents who chose to use more resources also had greater learning capacities, estimation of the amount learned per resource would be biased away from the null. Use of the randomized trial viewer did not appear to increase learning, but the amount of use was small enough that this result should be considered inconclusive.

In conclusion, the strategy of self-assessment–based study from guidelines holds promise, but further research is needed to maximize learners' motivation. Integration of quantitative evidence with guideline-based education may prove even more challenging.

REFERENCES

1. Field MJ, Lohr KN, eds. Guidelines for Clinical Practice. Washington, D.C.: National Academy Press, 1992.
2. Grol R, Zwaard A, Mokkink H, Dalhuijsen J, Casparie A. Dissemination of guidelines: which sources do physicians use in order to be informed? Int J Qual Health Care 1998; 10(2):135-40.
3. Kosecoff J, Kanouse DE, Rogers WH, McCloskey L, Winslow CM, Brook RH. Effects of the National Institutes of Health Consensus Development Program on physician practice. JAMA 1987; 258(19):2708-13.
4. Shiffman RN, Liaw Y, Brandt CA, Corb GJ. Computer-based guideline implementation systems: a systematic review of functionality and effectiveness. J Am Med Inform Assoc 1999; 6(2):104-14.
5. McDonald CJ, Overhage JM. Guidelines you can follow and can trust. An ideal and an example. JAMA 1994; 271(11):872-3.
6. Atkinson RC, Wilson HA. Computer-assisted instruction. Science 1968; 162(849):73-7.
7. Entwisle G, Entwisle DR. The use of a digital computer as a teaching machine. J Med Educ 1963; 38:803-12.
8. Hoffer EP. Computer-aided instruction in community hospital emergency departments: a pilot project. J Med Educ 1975; 50(1):84-6.
9. Harless WG, Duncan RC, Zier MA, Ayers WR, Berman JR, Pohl HS. A field test of the TIME patient simulation model. Acad Med 1990; 65(5):327-33.
10. Friedman CP, France CL, Drossman DD. A randomized comparison of alternative formats for clinical simulations. Med Decis Making 1991; 11(4):265-72.
11. de Dombal FT, Horrocks JC, Staniland JR, Gill PW. Simulation of clinical diagnosis: a comparative study. Br Med J 1971; 2(761):575-7.
12. Norman GR. Striking the balance. Acad Med 1994; 69(3):209-10.
13. Bell DS, Fonarow GC, Hays RD, Mangione CM. Self-Study from Web-Based and Printed Guideline Materials. A Randomized Trial among Resident Physicians. Ann Intern Med 2000; 132(12):938-46.
14. American College of Physicians. Guidelines for risk stratification after myocardial infarction. Ann Intern Med 1997; 126(7):556-60.
15. Ryan TJ, Anderson JL, Antman EM *et al.* ACC/AHA guidelines for the management of patients with acute infarction. J Am Coll Cardiol 1996; 28(5):1328-428.
16. Bell DS, Mangione CM. A System for Pilot Testing Clinical Knowledge Questions Using Pseudo-anonymous Electronic Mail. Proc AMIA Annu Fall Symp 1998; 971.