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Mark L. Graber [a]; David Tompkins [a]; Joanne J. Holland [a]
[a] VA Medical Center, USA

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Resources medical students use to derive a differential diagnosis

MARK L. GRABER, DAVID TOMPKINS & JOANNE J. HOLLAND
VA Medical Center, Northport and SUNY at Stony Brook, USA

Abstract

Background: Deriving an appropriate differential diagnosis is a key clinical competency, but there is little data available on how medical students learn this skill. Software resources designed to complement clinical reasoning might be asset in helping them in this task.

Aims: The goals of this study were to identify the resources third year medical students use to solve a challenging diagnostic case, and specifically to evaluate the usefulness of Isabel, a second-generation electronic diagnosis support system.

Methods: Third year medical students ($n = 117$) were presented a challenging case and asked to identify and prioritize their top 3 diagnoses, report the time devoted to the exercise, and list the resources they used and their relative usefulness. Students were randomized to receive (or not) free access, instruction, and encouragement to use to a web-based decision support system (Isabel).

Results: Students who identified the correct diagnosis as their first choice spent significantly more time on the case than did the other students (3.75 ± 0.28 hours vs 2.88 ± 0.15 hours, $p < 0.05$). Students used electronic resources extensively, in particular Google. Students who self-reported use of Isabel had greater success identifying the correct diagnosis ($24/33 = 73\%$ for users vs $45/84 = 53\%$ for non-users) a difference of borderline statistical significance.

Conclusions: These findings indicate that medical trainees use a wide range of electronic decision support products to solve challenging cases. Medical education needs to adapt to this reality, and address the need to teach future clinicians how to use these tools to advantage.

Introduction

A major goal of undergraduate medical education is to somehow teach the skill of clinical reasoning. This remains a challenge, because our understanding of medical decision making and how one acquires expertise in this skill is still evolving (Elstein & Schwarz 2002; Norman 2005; Sandhu & Carpenter 2006) and educators have not agreed on the best ways to teach these skills to inexperienced students (Goss 1996; Bowen 2006). Deriving an appropriate differential diagnosis requires an extensive knowledge base, skills in gathering the patient's history and performing the physical examination, and the ability to synthesize all of this information effectively. Medical students approach a diagnostic challenge with a limited knowledge base, a paucity of relevant experience, and typically without an organized problem-solving approach. Students are predisposed to making characteristic cognitive errors that experts avoid. For example, they don't always gather the appropriate history or physical findings, they report findings that aren't really there, and they have difficulty synthesizing information, such as how to use discriminatory findings (Friedman et al. 1998; Noguchi et al. 2002; Coderre et al. 2003).

Expert clinicians have well-developed metacognitive skills, and intuitively 'know' whether they are comfortable solving a new diagnostic challenge. Discomfort appropriately leads to consultation with other specialists, or research into the medical literature. Over the past decade, a host of electronic decision-support tools have become available that constitute an alternative resource for medical decision making. These tools are now available for personal computers, hand-held devices, and on the internet, and they have the potential to improve clinical decisions and the quality of medical care. In addition to classic texts and journals that have now evolved into electronic counterparts, clinicians can now use electronic foraging and search tools to help them find essential clinical information

Practice points

- Third year students use a wide variety of resources to arrive at the diagnosis for difficult cases and make extensive use of electronic resources, especially Google.
- Newer, web-based tools are available that provide support for medical diagnosis, such as the Isabel decision-support web site.
- The time spent on the case correlated with deriving the correct diagnosis in a difficult case. Use of Isabel tended to increase the ability to derive the correct diagnosis.
- Medical educators need to consider when and how to teach students the optimal use of decision support tools.

Correspondence: Mark L Graber, MD FACP, Chief, Medical Service – 111, VA Medical Center, Northport, NY, USA, 11768. Tel: 631 754-7907; fax: 631 544-5315; email: mark.graber@va.gov

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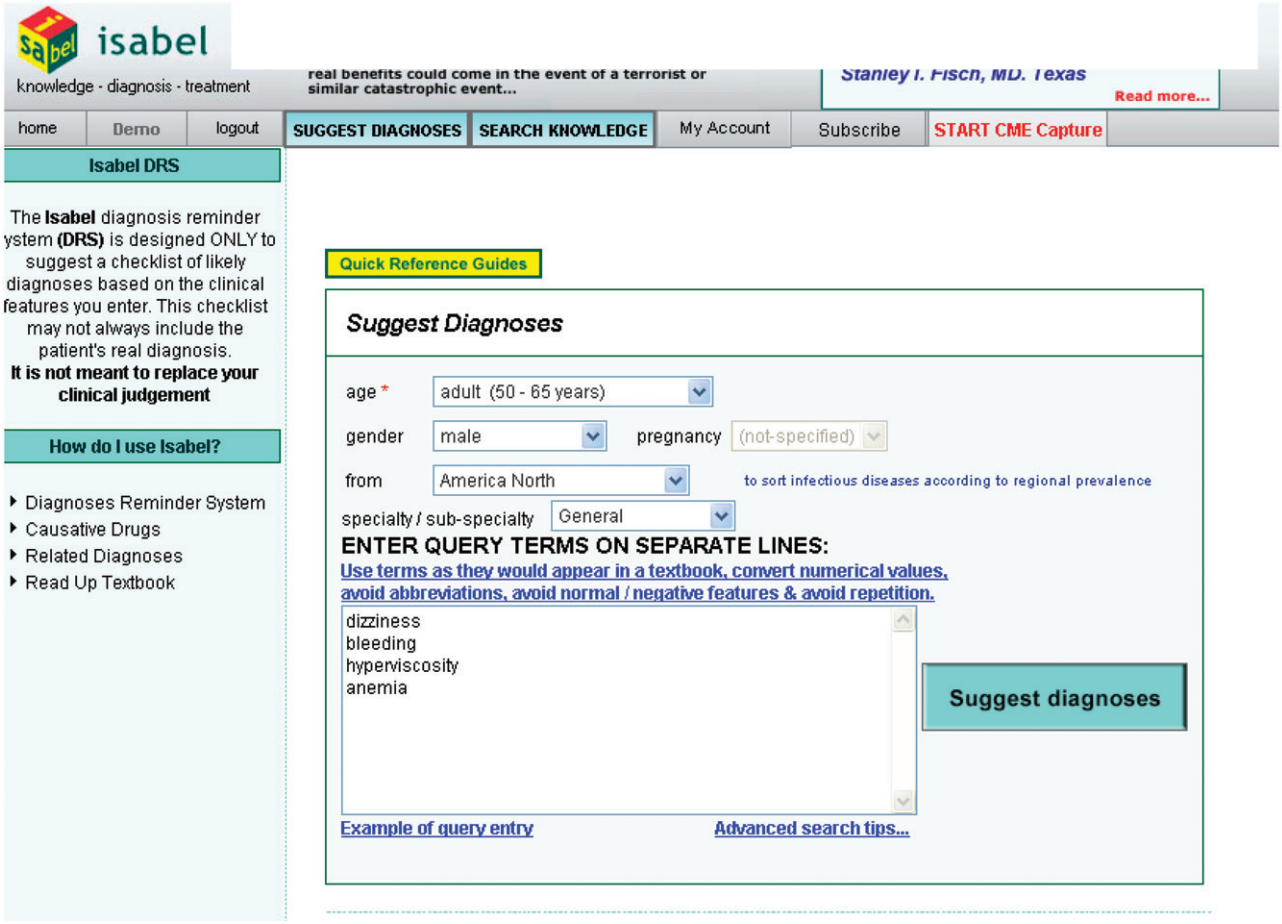

Figure 1. The data-entry screen of the Isabel diagnosis support software. The clinician manually enters the age, gender, locality, and specialty. The patient's key findings are entered as query terms.

needed at the point of care. In the specific area of clinical reasoning, several products are now available to help construct an appropriate differential diagnosis.

Because medical students struggle to construct appropriate and comprehensive lists of differential diagnoses on their own, one wonders whether the decision support tools designed for experienced clinicians would also be helpful to trainees. Although there is some evidence to the contrary (Hodges et al. 2001), we have observed that medical students do recognize their shortcomings, and take advantage of resources beyond their own cognitive skills if these resources are available. It is not clear, however, which resources they choose, and whether they use these effectively.

We therefore asked third year US medical students to 'solve' a challenging case in internal medicine, and to share the resources they used in this situation. A major goal was to determine whether they were aware of the newer electronic resources, and used them in their cases analyses. At the same time, we examined whether students would benefit from using 'Isabel', a second-generation web-based decision support program designed to facilitate clinical diagnosis. Isabel allows users to enter free text or key findings, and the program provides an ordered list of diagnoses to be considered. 'Isabel' (Isabel Healthcare Inc, USA) uses natural language processing to search relevant medical literature for the patient's key clinical findings. (See Figures 1 and 2). The program includes a thesaurus that facilitates recognition of terms. The search domain and results are filtered to take into account the patient's age, gender, geographic location, and pregnancy status, parameters that are pre-selected by the clinician. After entering the key findings from the case, relevant diagnostic considerations are then displayed 10–15 to a page for a total of 30 suggestions. The order of listing reflects an indication of the matching between the findings selected and the reference materials searched, but is not meant to suggest a ranked order of clinical probabilities. As in the first generation systems, more detailed information on each diagnosis can be obtained by links to authoritative texts. Isabel has been reported to display the actual diagnosis chosen by expert clinicians in 91% of test cases, and 95% of real cases (Ramnarayan et al. 2003).

Methods

Subjects were all medical students at SUNY Stony Brook beginning their 3rd academic year in July of 2005. At this point in their training, the students have completed all their basic science and pre-clinical courses, and a course on physical diagnosis. They start the rotations into patient-care settings in the third year, so participating students would have had 0–9

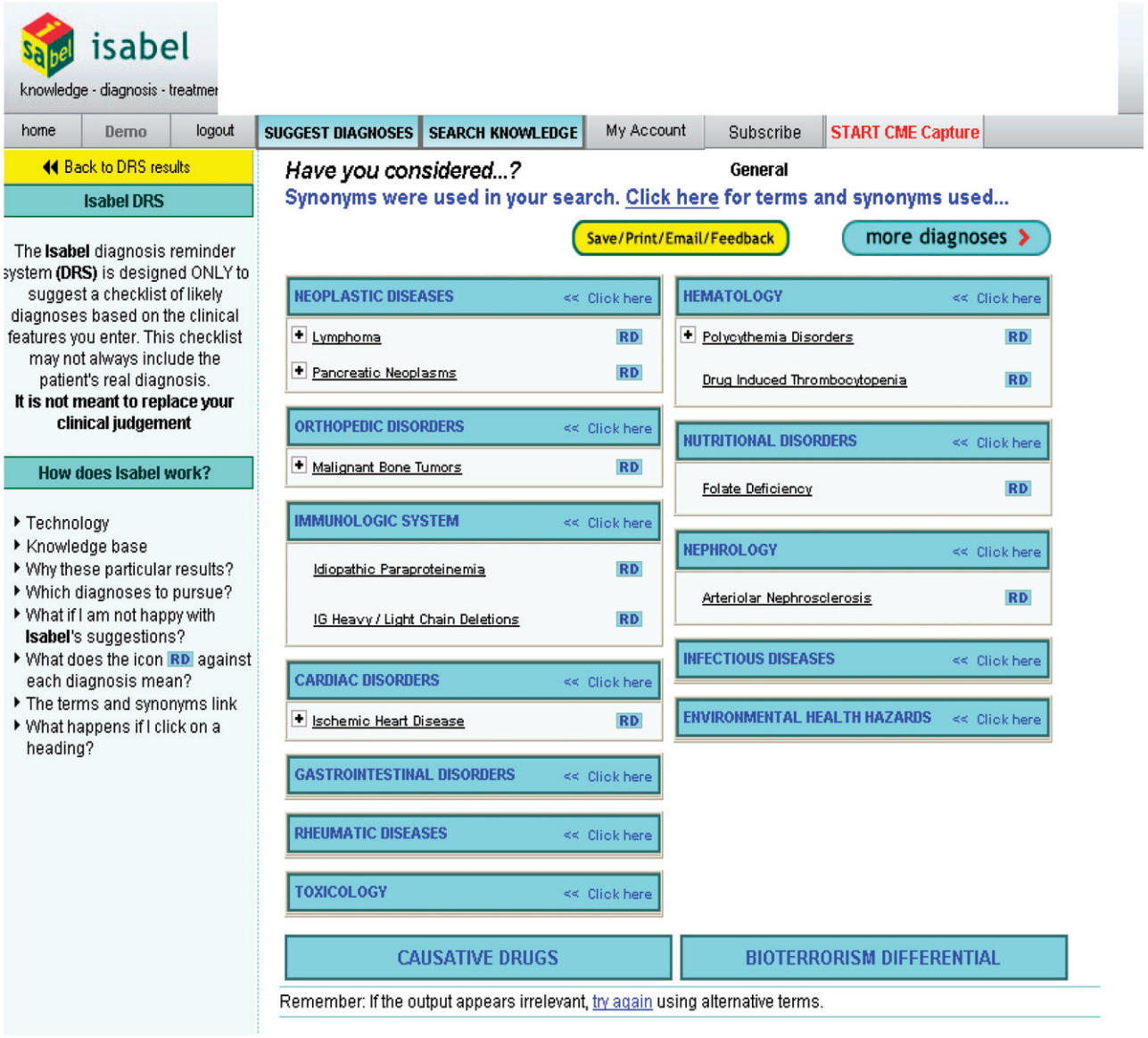

Figure 2. The first page of results of the Isabel diagnosis support software. Additional diagnoses are presented by selecting the 'more diagnoses' box.

months experience evaluating patients at the time of this study. The students were approached during the Medicine core rotation as part of a mandatory assignment to analyze a difficult case in internal medicine. The case was subsequently discussed as a 'Clinical-Pathological Correlation' (CPC) conference where the correct answer was revealed. The students participate in this exercise in blocks comprising approximately one-third of the class, and each block studied a different case. Students were randomized to either receive (or not receive) free web-based access to the ISABEL clinical decision support system (CDSS), along with instructions and brief encouragement to use this tool to help in solving the case.

All students were told that they could use whatever resources they chose to solve the cases, and were asked to identify the most likely diagnosis, and 2 other possibilities. They were asked to estimate how much time they devoted to the exercise, to identify any resources they used, if it was useful in suggesting relevant diagnoses they had not previously considered, and to rate the overall usefulness of the resource on a 1–5 Likert scale, where 1 = not helpful and 5 = extremely helpful. Six months after completing the study, a focus group was held with 5 of the Isabel-users to further explore their experience with this product.

Students were offered the option to not participate by contacting the principal investigator and participation was not considered in determining their grade on the exercise, which was rated as pass (diagnoses submitted) or fail (no diagnoses submitted). The consent and participation process was approved by the Institutional Review Board.

Analysis

The students perceptions of 'usefulness' were compared by analysis of variance and individual subgroups were compared using Student's *t* test assuming unequal variances and a two-tailed significance level of <0.05. The fractions of students who

Table 1. Resources used in solving an internal medicine CPC exercise.[a]

Resource	% of students who used it	% for whom the resource suggested the correct Dx	Rating of Usefulness[b]
Medical books	72.6	64.7	3.9 ± 0.13
Google	70.1	65.9	3.6 ± 0.14
Other students	69.2	69.1	3.5 ± −0.12
Journals	48.7	57.9	3.4 ± 0.15
Residents and attendings	29.1	61.8	3.4 ± 0.27
Isabel	28.2	60.6	2.6 ± 0.30*
eMedicine	15.4	61.1	4.0 ± 0.16*
Course materials	15.4	61.1	3.8 ± 0.32
Up-to-Date	14.5	70.6	3.8 ± 0.19

[a] Five other resources were reported but were only used once.
[b] Values are the mean of score of Likert values rated on a scale of 1 (not helpful) to 5 (extremely helpful). *= $p < 0.05$.

derived the correct diagnosis were compared by Pearson chi square analysis and by Fisher's exact test. Time spent per case was compared using Student's *t* test for equal variances.

Results

All 117 students agreed to participate in the study and of these 59 were chosen at random to receive free access to Isabel and instructions on its use. Only 33 students self-reported actual use of Isabel, all from the group who were assigned access. There were no differences among the 3 blocks, so the results were pooled.

Overall, 59% of the students included the correct diagnosis among their top 3 choices, and 46.2% listed the correct diagnosis as their first choice. Using an intention-to-treat analysis, the students given access to Isabel performed almost identically to those not given access in terms of both identifying the correct diagnosis at all (27/59 vs 27/58, NS), or as their top choice (34/59 vs 35/58, NS). The students who self-reported use of Isabel had greater success identifying the correct diagnosis at all (24/33 = 73% for users vs 45/84 = 53% for non-users, Fischer's exact test, $p = 0.064$; Pearson chi square 0.058) or as their first choice (20/33 = 61% for users, vs 34/84 = 40% for non-users, Fisher's exact test $p = 0.064$, Pearson chi square $p = 0.049$), differences of borderline statistical significance.

The students who identified the correct diagnosis as their first choice spent significantly more time on the case than did the other students (3.75 ± 0.28 hours vs 2.88 ± 0.15 hours, $p < 0.05$).

The resources used to research and solve the CPC cases are shown in Table 1, in order of how often they were used. Of non-electronic resources, the students tended to access medical texts, other students, medical journals, and residents/attendings. Of the electronic resources used more than once, Google was the most popular, followed by Isabel, eMedicine, and Up-to-Date. The resources were generally rated comparably in regard to 'Usefulness', i.e., how likely they were to suggest relevant diagnoses, although eMedicine was rated better than average and Isabel was rated below average.

A focus group discussion with 5 of the Isabel-users revealed that they found the product easy to use, helpful in confirming diagnoses they had already considered, and helpful in suggesting new diagnoses. A negative factor was that the 30 diagnostic considerations provided by Isabel was perceived as somewhat overwhelming; the students felt inadequate to the task of knowing which of the suggestions could be disregarded.

Discussion

Our study examined the problem-solving approaches of third year medical students beginning their clinical rotations. The results show that they use a variety of resources to derive an appropriate differential diagnosis including their medical textbooks, their peers and teachers, and a variety of electronic resources. Surprisingly, GOOGLE was the electronic resource used most frequently, exceeding by a substantial fraction the use of Isabel, eMedicine, and Up-to-Date. Although GOOGLE has been reported to be useful in solving isolated clinical cases (Tang & Ng 2006), the search is not optimized for medically-relevant conditions. The only published study of Google reported a sensitivity of 58% in suggesting the correct diagnosis, substantially below the sensitivity reported for Isabel, which is generally over 90% (Ramnarayan et al. 2003). Moreover, access and data entry are rapid using Isabel, and the diagnoses suggested are likely to be highly relevant (Ramnarayan et al. 2004).

A similar observational study recently examined how 3rd year residents in family medicine solved clinical questions (McCord et al. 2007). Of 12 possible resources, (texts, journals, consultants, colleagues, etc) the residents self-rated electronic decision support resources as the ones they would use most often. When observed in practice, however, colleagues and preceptors were also used extensively. ISABEL has only been evaluated once in a training setting, a small study of 15 students. The students found ISABEL helpful, and the tool provided at least one additional diagnostic consideration 66% of the time (Nazarian et al. 2005).

It is increasingly recognized that efforts to optimize patient safety should begin with medical trainees (Henriksen & Dayton 2006). Medical education presents an ideal opportunity to provide future clinicians with the values, knowledge, and skills necessary to develop a culture of patient safety, and safe medical practice. In regard to diagnosis, to the extent that we can teach medical students the skills of medical decision making, the less likely they will be to make diagnostic errors when they enter practice. Diagnostic errors in medicine typically have cognitive origins (Kuhn 2002; Graber et al. 2005). In our recent study of diagnostic errors involving

internists, errors of synthesis were substantially more common than deficits of medical knowledge or problems gathering accurate data. Of all the synthesis errors, the two most common were (a) premature closure (the tendency to stop thinking about alternative diagnoses once a working diagnosis is established) and (b) context errors (where the clinician constructs the wrong context for the case and fails to examine other contexts) (Graber et al. 2005). These tendencies relate to clinicians inclination to solve problems by 'satisficing', accepting the first diagnosis that seems to adequately explain all the facts at hand, without a conscious consideration of other possibilities.

Clinical decision support systems (CDSS) have the potential to ameliorate these cognitive tendencies by assisting the clinician to consider a broader range of different diagnostic possibilities. CDSS's have been available for several decades but have not been widely adopted clinically (Berner et al. 1994; Hunt et al. 1998). Many different reasons have been cited: Physicians don't believe the products will help them, they believe using these programs will require too much time and effort, and older clinicians in particular are uncomfortable using electronic decision support resources. We reasoned that medical students would be more receptive to using a web-based electronic CDSS compared to practicing clinicians. Despite the emphasis given to the Isabel CDSS in the course of this study, students rate its 'usefulness' below average. The focus group findings suggest several factors seem most likely as possible explanations: (a) Students have extensive familiarity with using GOOGLE, as opposed to the other electronic resources, (b) They are somewhat overwhelmed by the 30 different diagnostic considerations presented by Isabel, and (c) They are just beginning to solve clinical problems and are not adept enough in this skill to accurately compare various decision-support resources. From this perspective, it is reasonable to hypothesize that the utility of Isabel would increase in proportion to the fund of knowledge of the user: An expert clinician would be able to more easily discern relevant from irrelevant suggestions than a medical student just beginning their clinical exposure.

The major limitations of this study include its small size, the limited instruction in using Isabel, and the possibility for cross-contamination. Although none of the students not assigned to the Isabel-usage group reported using it, students interact freely with each other and are likely to discuss their diagnostic considerations and what tools they are using to help reach these considerations. Our intervention to encourage use of one electronic CDSS may have indirectly stimulated general interest in the use of other electronic resources. Finally, other schools of medicine might differ in ways that could affect these results. For example, schools could differ in how easy or hard it is to access electronic resources, how effectively the students interact with residents and staff physicians, and how competitive the students are.

Our study has interesting implications for medical education. The results suggest that trainees are aware of electronic resources but are not adept at using them, and choose resources such as Google, which in comparison to the other e-resources is not specifically designed to facilitate medical diagnosis and does not preferentially link to authoritative medical resources. Alternatively, the students' facility in using Google may more than compensate for these shortcomings.

Medical educators therefore face the substantial challenge of learning about these new resources, comparing their efficacy in relation to whatever traditional resources they used in the past, and deciding when and how to incorporate these into the medical curriculum. Besides incorporating the use of electronic resources into traditional courses, medical schools also need to consider providing specialized courses on the optimal use of these products. By using clinical case material to teach these skills, this type of instruction could help students attain competency in clinical reasoning skills, using an engaging format.

Recent perspectives suggest that successful clinicians are information managers, not knowledge repositories. Clinicians adept at information management use electronic resources to both keep up with the advances in the medicine and to find essential information needed at the moment in regard to a particular case or clinical questions (Slawson & Shaughnessy 2005). Trainees need to be exposed to these tools and learn how to use them most effectively. Medical educators will therefore need to learn how to teach these skills and consider where and when in the educational continuum to present this material. This last issue is hardly straightforward, as illustrated in our own study: the focus group findings suggest that exposure and training in use of Isabel should probably be deferred until later in the clinical training years, when the students have a larger repertoire of knowledge and experience.

In summary, our study indicates that medical trainees use and misuse electronic decision support products in deriving a differential diagnosis for a challenging cases. Medical education needs to adapt to this reality, and address the need to teach future clinicians how to use these tools to advantage.

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Notes on contributors

Dr MARK GRABER is Chief of Medical Service at the Northport VA Medical Center in Northport, New York and Associate Chair of the Department of Medicine at SUNY Stony Brook. Dr Graber co-chairs the Department of Veteran's Affairs Decision Support Committee, and has a research interest in reducing diagnostic errors in medicine.

DR JOANNE HOLLAND is Associate Chief of Medicine at the Northport VA Medical Center and is actively involved in trainee education at all levels.

Dr DAVID TOMPKINS is the Vice Dean for Student Affairs at SUNY Stony Brook and coordinates the experience of all medical students during their Medicine rotations.

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