

DAVID WESTFALL BATES, MD: a conversation with the editor on improving patient safety, quality of care, and outcomes by using information technology

David Bates (Figure 1) was born in Madison, Wisconsin, on June 5, 1957. Early on, his family moved to Tucson, Arizona, and he grew up there. He graduated from Stanford University in 1979 and from the Johns Hopkins University School of Medicine in 1983. His internship and residencies in internal medicine were at the Oregon Health Sciences University in Portland, Oregon. He stayed on the faculty there briefly and then went to the Brigham and Women's Hospital (BWH) in Boston, Massachusetts, as a research/clinical fellow in medicine. After completing that training in 1990, he stayed on the faculty of Harvard Medical School. In 2003, he was appointed full professor of medicine with a joint appointment as professor in the Harvard School of Public Health, Department of Health Policy and Management. In 1998, he became chief of the Division of General Internal Medicine in the Department of Medicine of the BWH. He also serves as medical director of clinical and quality analysis for Partners Healthcare Systems and briefly was medical director of the BWH physician-hospital organization. In 2001, he became editor in chief of the *Journal of Clinical Outcomes Management*.

Dr. Bates has written extensively in the areas of clinical decision making, quality of care, cost-effectiveness, outcome assessment, and the use of computerized interventions to affect physician behavior. His original articles in peer-reviewed medical journals number nearly 175, and his reviews, monographs, and editorials number nearly 100. For his contributions he has received a number of awards, including the Henry Christian Award for Excellence in Research from the American Federation of Clinical Research, the Cheers Award for Outstanding Contribution to Medication Error Prevention from the Institute for Safe Medication Practices, and the John M. Eisenberg Award for Patient Safety Research from The National Quality Forum. Dr. Bates is the father of 2 promising children and is an avid bird watcher and mountain climber. He is also a nice guy, and he honored Baylor University Medical Center (BUMC) by his recent visit.

William Clifford Roberts, MD (hereafter, WCR): Dr. Bates, I appreciate your willingness to talk to me and therefore to the readers of BUMC Proceedings. You have certainly been a leader in improving patient safety and outcomes using information technology. How did you get started in this arena?

David Westfall Bates, MD (hereafter, DWB): When I was in high school in Tucson, Arizona, I worked as a programmer. At Stanford University I was active at the computing facilities.



Figure 1. Dr. David W. Bates during the interview. Photo: WCR.

My computing skills were essentially not utilized during medical school. During my residency in Oregon, we had to find the laboratory results by going through a big pile of slips! By the time I arrived in Boston for fellowship, computers were beginning to be used more for routine purposes. During my fellowship at the BWH, I began thinking about implementing computerized physician order entry (CPOE). By that time I had gotten very interested in physician decision making. My fellowship project focused on assessing when blood

cultures should be performed (Bates, *Ann Intern Med*). During that time, I became increasingly interested in using hospital computer systems to improve decision making. It seemed that if we could use computers to order tests and drugs, efficiency and safety would improve.

Around that time the results of the Medical Practice Study were released (Brennan, *N Engl J Med*). That large study looked at the frequency of adverse events in the state of New York. It showed that 3.7% of patients who were hospitalized in New York had suffered an adverse event, and about half of those adverse events were preventable. The single leading cause of adverse events was adverse drug events, which seemed to represent an opportunity for improving safety.

A leading author of the Medical Practice Study was Lucian Leape, who was at the Harvard School of Public Health. I met with him and discussed medicine safety. Together with Dr. David Cullen, we designed the Adverse Drug Event Prevention Study, a series of studies that examined the frequency and preventability of adverse drug events in inpatients. Our first study found that there were 6.5 adverse drug events for every 100 patients admitted to the hospital, and 28% of the events were preventable (Bates, *JAMA*, 1995). Most of the preventable adverse events were caused by errors in the ordering or prescribing stage of the process.

That study spoke well for implementing CPOE, which we were thinking about doing at the time. CPOE was implemented at the BWH beginning in 1993. We subsequently studied CPOE's impact on serious medication errors and found that CPOE reduced the serious medication error rate by 55% (Bates, *JAMA*, 1998).

WCR: *Was the CPOE system initiated at the BWH in 1993 accepted throughout the hospital relatively quickly?*

DWB: Yes, it was. It took a few years to spread CPOE through the whole hospital. We started with the medicine department and later implemented it in surgery and then obstetrics and gynecology. We started with medicine in part because all of the orders in the department have to be written by the housestaff, so that was a relatively easy place to start. In surgery, many orders are also written by attending physicians. In obstetrics and gynecology, even more orders are written by attendings. In obstetrics, we also have many clinicians at the hospital for a small part of their time so that was a particular challenge.

WCR: *How long did it take to implement the system in the entire hospital?*

DWB: Some tiny niches of it took a long time. The neonatal intensive care unit, for example, came on line in 2001, 8 years after the medicine department. We subsequently implemented CPOE at the Massachusetts General Hospital, and we were able to go more rapidly there than we had at the BWH because we had already learned how to solve many of the problems.

WCR: *Cedars-Sinai Hospital in Los Angeles went on the CPOE system much later than you did, and they had major problems. What were the major problems?*

DWB: They had several issues. One was that they displayed a lot of drug-drug interactions on the screen, and the clinicians found that extremely annoying. Unfortunately, because of the way things had been set up, they were unable to selectively decrease the number of drug interactions that they showed. Another issue was that they made the decision to try and fix problems as they went along, on the fly, and clinicians also found that upsetting. Finally, the physician group at Cedars-Sinai Hospital is challenging because it includes many private attendings who spend only a small proportion of their professional lives in the hospital.

WCR: *You must have been pleased when President George W. Bush mentioned the CPOE system in his State of the Union address in January 2004. Who got that in there?*

DWB: Yes, I was delighted. I think it may have had something to do with Bill Yasnoff, who is in the Department of Health and Human Services. The president has been a supporter of electronic health records for some time. I was very pleased that it got his attention and support. Secretary Thompson has been very supportive of electronic health records also.

WCR: *What other interventions can improve safety in the hospital?*

DWB: One is the “smart pump,” which knows or can be told what drug is being administered. If the nurse tries to administer too high a dose, the pump warns the nurse. We have just completed a study of the impact of smart pumps on serious medication errors. The smart pump’s “black box” function allows tracking of all of the warnings and responses so you can later figure out exactly what happened. That has proved to be very interesting and useful.

Another technology that is very promising is *barcoding* coupled with computerized medication administration records. This technology is used increasingly around the country. The evidence of benefit, however, is less solid than for some other technologies. We are currently studying the impact of barcoding on drug administration safety.

Computerized adverse drug event monitoring is another useful technology. The computer checks the database for signals of interest, such as use of an antidote or identification of a high serum drug level. If a signal is identified, the drug safety pharmacist is notified, and he or she investigates the incident. That has helped us identify many more adverse drug events than before and has allowed the pharmacist to intervene before the patient suffers additional harm or an important problem. We estimate that we’re saving about \$900,000 a year as a result of interventions that the pharmacist implements at the BWH.

WCR: *How do you figure the \$900,000?*

DWB: We count up the number of interventions and measure the cost associated with an adverse drug event. In 1997, the cost of a preventable adverse drug event at the BWH was around \$5600; it is more today. Thus, the costs associated with these problems are substantial.

WCR: *You’ve done a number of studies on communication of laboratory results.*

DWB: Before initiating the “panic” laboratory study—“panic” results being those that need to be dealt with rapidly, such as high or low serum sodium, potassium, or glucose levels—we found that it took >5 hours for providers to take some action in response to about 25% of these abnormal values. We implemented an intervention in which the covering physicians were paged to inform them of the abnormal results, and the time from identification of the abnormal laboratory value to initiation of therapy dropped substantially. The physicians nearly uniformly reported that they were pleased with the intervention. To initiate the panic laboratory procedure, we had to build a *coverage list*, which proved to be remarkably useful for a whole variety of things. This list keeps track of which physician is responsible for every patient at a given time. I don’t know of another hospital in the country that has built a tool to do this, unfortunately, despite its value.

WCR: *How does this tool help?*

DWB: It lets you know “who’s on first” so you know whom to call. The usual approach is for the laboratory to call the ward secretary. But then the secretary may not know how important a potassium level of 7.3 mEq/L is.

WCR: *Is that how your computerized sign-out application essentially got started?*

DWB: Not surprisingly, the sign-out application works very closely with coverage lists. The application basically lets one provider sign out to another using the computer system. In an earlier study we found that patients who were being treated by a cross-covering physician rather than their regular physician had a 5-fold elevated risk of having an adverse event. After we implemented the computerized sign-out application, that relative risk went back to 1. We believe the reason is that now the covering providers have more information about patients when they are taking care of them.

WCR: *What happens when a physician signs out to another physician?*

DWB: It’s quite variable. Often in systems in which transfers are done on paper, relatively little information is exchanged—it might be simply a list of the patients with one word about their diagnosis. That brief information often is insufficient. With this application, though, the covering physician gets a “snapshot” about each patient, including his or her problem list, medica-

tions, recent laboratory results, and a summary of what is going on. Much of this information is pulled from the hospital computer system.

WCR: *If a patient is in critical care, you can go into more detail. The signing out can be done entirely on the computer without face-to-face contact with the cross-covering physician?*

DWB: We still have a face-to-face encounter, which is important because it allows emphasis of a few things. In addition, the physician gives a print-out with detailed information to the cross-covering physician, who can then use that paper or look up the same information on the computer. We recently examined exchange of information for patients moving from the recovery room to a pediatric intensive care unit. Although we are still analyzing the data, the study has been quite revealing. Often, important pieces of information are not communicated. Communication is absolutely pivotal for delivering good care, and we need to figure out how to do that better.

WCR: *You have studied physician fatigue (housestaff fatigue). Can you discuss the impact of fatigue on patient care?*

DWB: Our recent study focused on evaluating the impact of an intervention to eliminate extended duty shifts, those ≥ 24 hours, in the medical intensive care unit (Landrigan, *N Engl J Med*). It is clear from evidence in other areas that if a physician is awake for a long period of time, the error rate increases. Until we did this recent study, a scientific study had not been done that demonstrated increased errors in clinical care, although many studies suggested that performance would fall with sleep deprivation. We found that houseofficers made 30% more serious errors when they were fatigued than when they were not.

WCR: *How did you define "error"?*

DWB: We used the definition from the 1998 Institute of Medicine report: an error is "an unintended action or failure to carry out a completed plan." As an example, an intern was preparing for a thoracentesis. The resident walked in and found that the intern was about to tap the wrong side of the chest.

WCR: *You have done a lot of studies on clinical decision making. What decision making are you talking about primarily?*

DWB: A lot of the work we've done has focused on drugs, but we've also done studies on testing and radiographs. For example, we provide a variety of decision supports to physicians when they order a test. We show them the cost of the test, we indicate if the test appears to be redundant, and we make suggestions about which test to do. With radiographs, we've provided some structuring of the reasons why physicians order radiographs, and then we present guidelines about the radiographs. We've looked at the impact of all of this and how physicians actually make decisions.

WCR: *How many decisions does an average internist make each day seeing patients from 8:00 AM to 5:00 PM?*

DWB: That's a great question and I don't know the answer, but my guess is that it is several hundred each day.

WCR: *You have a large group of physicians in your general medicine division, and most see patients every day. Are they the ones that you have studied more than any other group, or do you study the cardiologists, endocrinologists, and other specialists or subspecialists?*

DWB: We study everybody. In the inpatient setting, we study all of the clinicians who practice in the hospital, everyone who uses the computer system. In the outpatient setting (that's where

we are doing most of our work now), we study everyone who uses the computer system. Currently, that includes the internists and a number of groups of medical specialists—the oncologists, the rheumatologists, the infectious disease group, etc. Soon at the BWH all physicians will be using the outpatient computer system as well.

WCR: *The studies you have done in the hospital are now being transferred to the outpatient area?*

DWB: Yes.

WCR: *What are your plans for the next few years?*

DWB: I'm very excited about health care policy with respect to information technology. We have set up a group in Massachusetts called the Massachusetts E-Health Collaborative, which includes the payers, the purchasers, the providers, the malpractice carriers, the state government, and other key stakeholders. The intent is to increase the use of electronic health records in Massachusetts and to implement clinical data exchange in the state.

WCR: *What does the phrase "clinical data exchange" mean?*

DWB: It means moving pieces of clinical data across boundaries—for example, from a physician's office or a large physician group to a hospital and vice versa. We have gotten \$50 million from Blue Cross to get started. We are in the process of selecting 3 communities in Massachusetts to initiate this endeavor. Later, we plan to implement this exchange across the whole state of Massachusetts.

WCR: *If you are a practicing internist at the BWH, can you check the computer for the status on all of your hospitalized patients before you go to bed at night or before you leave your home for the hospital in the morning?*

DWB: Yes. We find that physicians log in from home all the time. Clinicians can't imagine not having this access to their hospitalized patients at this point.

WCR: *You have a hospitalists program at the BWH. I am surprised that you do in light of the large number of housestaff there. How does your hospitalist program work?*

DWB: Hospitalist programs have been very successful, and they are very well received.

WCR: *Are there full-time hospitalists at the BWH?*

DWB: Yes. Many of them do all of their clinical work as hospitalists and then do research with our group as well.

WCR: *Are the hospitalists in your division?*

DWB: Yes. Early data suggest that hospitalists may have better outcomes than providers who spend less time delivering inpatient care. A multicenter study is now in progress to address this question in more detail.

WCR: *Have the practitioners in general been pleased with the hospitalist program?*

DWB: Yes, definitely. There are still bumps in the road at times and issues about exchanging information between the referring primary care providers and the hospitalists and then back from the hospitalists to the referring primary care physicians.

WCR: *You must be getting offers to be chairman of departments of medicine here and there. I can't imagine anyone better prepared to take on that role.*

DWB: I enjoy what I do, and being chair of a department of medicine has a lot of headaches associated with it. I was the medical director of our physician-hospital organization, and that taught me a lot about the business of medicine. I got a lot of useful

skills from doing that as well. Yes, it is very valuable interacting with so many different groups.

WCR: *How did you get to be such an expert in computers? When you graduated from college, you were a chemist.*

DWB: I learned most of what I know about computers by the seat of my pants. I did research on computer entry and on computing systems and worked at the interface between the information technology group and the clinical group for a number of years. By doing that I learned a lot about information technology. Eventually, I started going to the information technology meetings regularly because most of my research was on evaluating the impact of information technology. I eventually got elected to the American College of Medical Informatics (which is the honorary society of informatics), and I've been very active in that group. I just got elected to the board of the American Medical Informatics Association.

WCR: *What time do you wake up in the morning?*

DWB: I get up around 6:00 AM, have breakfast, say goodbye to the kids, and get to work around 7:30 AM. What I do varies and depends on the day. I have a role as a director of information technology, and so 2 days I'm out at my information technology office for half of the day.

WCR: *How far is that from the BWH?*

DWB: It's about 14 miles. The computer systems themselves are at the BWH, but the people who write all of the applications are now offsite.

WCR: *Is your division just at the BWH or does it include the physicians at the Massachusetts General Hospital as well?*

DWB: My division is just at the BWH, but the division includes many community practices in a variety of locations. Most of the week I'm at my BWH-based office doing things related to the general internal medicine division. I have a very active research program. We have a center of excellence in patient safety. We have 6 studies going on now that are a part of that. I see patients one half day a week. Typically, I leave the hospital at around 6:00 PM, and I'm home by 6:30 or so.

WCR: *What do you do at night?*

DWB: At night, I spend time with my family. I have 2 kids, 13 and 15.

WCR: *Do you do much professional work at night?*

DWB: I do some but relatively little.

WCR: *What about Saturday and Sunday?*

DWB: On Saturday and Sunday, I often come in and work. I work at least one day of most weekends.

WCR: *Because of the arena you are in and your major contributions to it, you must be highly sought after for consultations from many medical centers. How much do you travel now for consultations, talks, meetings, etc.?*

DWB: I'm very selective about which consultations I do. I don't do as many of them as I used to. I travel about 2 or 3 times a month for one thing or another. Usually I'm away for only 1 or 2 days. On trips to Washington, DC, I usually return the same day.

WCR: *How much time do you take off a year?*

DWB: I take off 4 weeks a year. Recently, our family had a 3-month sabbatical in Australia where I learned about the spread of the electronic health record in primary care there (Figure 2). They used an incentive-based approach and went from 20% adoption

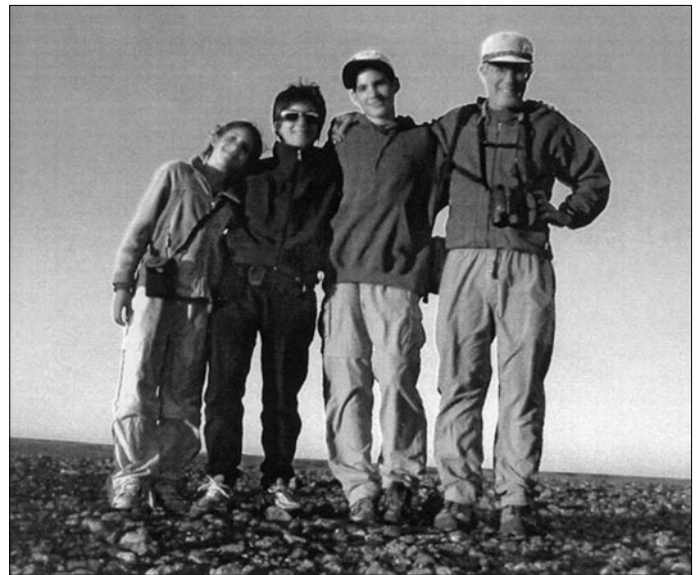


Figure 2. Sarah, Carol, Michael, and David Bates in the Outback, 2004.

to 80% adoption in around 2 years. I met with the leaders of that effort. The key things that they did were giving providers a modest grant (about \$2000) for beginning to use electronic records and giving them the opportunity to buy hardware at a discount. They also helped providers set up the application. The support to the practitioners was superb. The United Kingdom used a different approach, paying for electronic health records. They have spent £8 billion implementing electronic health records. In the UK at this point, only 70 providers in the entire nation are not computerized.

WCR: *So they are way ahead of the USA?*

DWB: Yes, and most industrial countries are. I am the chairman of the National Alliance for Primary Care Informatics, which is a coalition of primary care societies in the USA, and our main focus is to increase the use of electronic health records in primary care. We have a lot of catching up to do.

WCR: *What is medical practice going to be like at the BWH in 2010, 6 years from now?*

DWB: It will be different than it is today. We've recently implemented something called the Signature Initiatives led by our chief executive officer, Jim Mongan. There are 6 parts to the Signature Initiatives, but they focus on many of the areas that we have been talking about. All areas focus on improving the quality, safety, and efficiency of care that we deliver. The first initiative focuses on information technology. That will involve implementing CPOE in all the hospitals in our network, including the smaller hospitals. The second part involves extending electronic health records to all of our providers in Partners. I think by 2010 (and perhaps sooner), all the providers in Partners will be using electronic health records. We will be getting better decision support than we're delivering now, and that will substantially shorten the time that it takes us to get evidence-based medicine into practice. Providers will like practicing with electronic records. It will be like going to the ATM. You won't be able to imagine how you lived without using them. Outpatients will get more reliable, high-quality care than they get today. A recent study from RAND suggested that your chance of getting high-quality care in the USA was no better than a coin-flip (McGlynn, *N Engl J*



Figure 3. At the summit of Kilimanjaro in 2004.

Med). I think we will be able to get a lot better quality across a wide range of parameters.

WCR: *Do you have hobbies?*

DWB: I do. I'm very interested in birds. I have been all over the world and have seen about half the world's birds. I like mountain climbing and have climbed worldwide. This summer our family attempted to climb Mount Kilimanjaro, though only my wife and I reached the summit (Figure 3). I climb mountains all over the world. I coach my daughter's youth soccer team. Our family also loves to ski.

WCR: *You are 47 now. What are your goals between now and age 60?*

DWB: I'd like to continue doing some of the things I'm doing now. I feel like I have the best job in general medicine in the country, and I am having a tremendous amount of fun seeing the use of information technology grow and spread. There is still an enormous amount to be worked out about how to deliver decisions. I think pharmacogenomics will be extremely important. It will be very useful to start to begin to bring genetic information to primary care. I want to see my kids get off to college successfully.

WCR: *What did your father do?*

DWB: He was chairman of organic chemistry at the University of Arizona for many years.

WCR: *Did your mother work?*

DWB: She did. She was a systems analyst for the Indian Health Service and worked all over the West.

WCR: *So she's a computer expert herself?*

DWB: She is.

WCR: *Computers didn't come along until you were grown?*

DWB: Yes, I was already out of the house. My mother was working with computers all of the time but I wasn't—those were the punch-card days!

WCR: *Your parents still live in Arizona?*

DWB: Yes. In Tucson.

WCR: *Is there anything that you would like to discuss that we haven't touched on?*

DWB: No, I think we hit the high points.

WCR: *On behalf of BUMC Proceedings, I want to thank you very much, Dr. Bates, for allowing me to pick your brain a bit. You have been very open, and I think the readers will enjoy this.*

DWB: Thanks very much. It's been a pleasure.

DWB'S BEST PUBLICATIONS AS SELECTED BY HIM

(Publications are numbered according to his curriculum vitae.)

3. Bates DW, Cook EF, Goldman L, Lee TH. Predicting bacteremia in hospitalized patients. A prospectively validated model. *Ann Intern Med* 1990;113:495–500.
4. Bates DW, Goldman L, Lee TH. Contaminant blood cultures and resource utilization. The true consequences of false-positive results. *JAMA* 1991;265:365–369.
5. Bates DW, Lee TH. Rapid classification of positive blood cultures: prospective validation of a multivariate algorithm. *JAMA* 1992;267:1962–1966.
6. Bates DW, Leape LL, Petrycki S. Incidence and preventability of adverse drug events in hospitalized adults. *J Gen Intern Med* 1993;8:289–294.
7. O'Neil AC, Petersen LA, Cook EF, Bates DW, Lee TH, Brennan TA. Physician reporting compared with medical record review to identify adverse medical events. *Ann Intern Med* 1993;119:370–376.
8. Bates DW, Schmitt W, Buchwald D, Ware NC, Lee J, Thoyer E, Kornish RJ, Komaroff AL. Prevalence of fatigue and chronic fatigue syndrome in a primary care practice. *Arch Intern Med* 1993;153:2759–2765.
10. Bates DW, Lee TH. Projected impact of monoclonal anti-endotoxin antibody therapy. *Arch Intern Med* 1994;154:1241–1249.
13. Bates DW, O'Neil AC, Boyle D, Teich J, Chertow GM, Komaroff AL, Brennan TA. Potential identifiability and preventability of adverse events using information systems. *J Am Med Inform Assoc* 1994;1:404–411.
15. Bates DW, Buchwald D, Lee J, Kith P, Doolittle T, Rutherford C, Churchill WH, Schur PH, Wener M, Wybenga D, Winkelman J, Komaroff AL. Clinical laboratory test findings in patients with chronic fatigue syndrome. *Arch Intern Med* 1995;155:97–103.
16. Bates DW, Pruess KE, Lee TH. How bad are bacteremia and sepsis? Outcomes in a cohort with suspected bacteremia. *Arch Intern Med* 1995;155:593–598.
17. Bates DW, Boyle DL, Vander Vliet MB, Schneider J, Leape L. Relationship between medication errors and adverse drug events. *J Gen Intern Med* 1995;10:199–205.
18. Bates DW, O'Neil AC, Petersen LA, Lee TH, Brennan TA. Evaluation of screening criteria for adverse events in medical patients. *Med Care* 1995;33:452–462.
19. Bates DW, Pruess K, Souney P, Platt R. Serious falls in hospitalized patients. Correlates and resource utilization. *Am J Med* 1995;99:137–143.
20. Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Galloway T, Hallisey R, Ives J, Laird N, Laffel G, Nemeskal R, Petersen LA, Porter K, Servi D, Shea BF, Small SD, Sweitzer BJ, Thompson T, Vander Vliet M. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA* 1995;274:35–43.
21. Bates DW, Cullen DJ, Laird N, Petersen LA, Small SD, Servi D, Laffel G, Sweitzer BJ, Shea BF, Hallisey R, Vander Vliet M, Nemeskal R, Leape LL. Incidence of adverse drug events and potential adverse drug events: implications for prevention. ADE Prevention Study Group. *JAMA* 1995;274:29–34.
22. Schoenenberger RA, Tanasijevic MJ, Jha A, Bates DW. Appropriateness of antiepileptic drug level monitoring. *JAMA* 1995;274:1622–1626.
23. Cullen DJ, Bates DW, Small SD, Cooper JB, Nemeskal AR, Leape LL. The incident reporting system does not detect adverse drug events: a problem for quality improvement. *Jt Comm J Qual Improv* 1995;21:541–548.
25. Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? *Med Care* 1996;34:73–84.
26. Lee F, Teich JM, Spurr CD, Bates DW. Implementation of physician order entry: user satisfaction and self-reported usage patterns. *J Am Med Inform Assoc* 1996;3:42–55.
27. Leape LL, Hilborne LH, Schwartz JS, Bates DW, Rubin HR, Slavin P, Park RE, Witter DM Jr, Panzer RJ, Brook RH. The appropriateness of coronary artery bypass graft surgery in academic medical centers. Working Group of the Appropriateness Project of the Academic Medical Center Consortium. *Ann Intern Med* 1996;125:8–18.
28. Ellis RP, Pope GC, Iezzoni L, Ayanian JZ, Bates DW, Burstin H, Ash AS. Diagnosis-based risk adjustment for Medicare capitation payments. *Health Care Financ Rev* 1996;17:101–128.
29. Komaroff AL, Fagioli LR, Doolittle TH, Gandek B, Gleit MA, Guerriero RT, Kornish RJ II, Ware NC, Ware JE Jr, Bates DW. Health status in patients with

- chronic fatigue syndrome and in general population and disease comparison groups. *Am J Med* 1996;101:281–290.
31. Katz DA, Bates DW, Rittenberg E, Onderdonk A, Sands K, Barefoot LA, Snyderman D. Predicting *Clostridium difficile* stool cytotoxin results in hospitalized patients with diarrhea. *J Gen Intern Med* 1997;12:57–62.
 32. Bates DW, Spell N, Cullen DJ, Burdick E, Laird N, Peterson LA, Small SD, Sweitzer BJ, Leape LL. The costs of adverse drug events in hospitalized patients. *JAMA* 1997;277:307–311.
 34. Sands KE, Bates DW, Lanken PN, Graman PS, Hibberd PL, Khan KL, Parsonnet J, Panzer R, Orav EJ, Snyderman DR, Black E, Schwartz JS, Moore R, Johnson BL, Platt R. Epidemiology of sepsis syndrome in 8 academic medical centers. *JAMA* 1997;278:234–240.
 35. Harpole LH, Khorasani R, Fiskio J, Kuperman GJ, Bates DW. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4:511–521.
 36. Bates DW, Sands K, Miller E, Lanken PN, Hibberd PL, Graman PS, Schwartz JS, Kahn K, Snyderman DR, Parsonnet J, Moore R, Black E, Johnson BL, Jha A, Platt R. Predicting bacteremia in patients with sepsis syndrome. *J Infect Dis* 1997;176:1538–1551.
 37. Cullen DJ, Sweitzer BJ, Bates DW, Burdick E, Edmondson A, Leape LL. Preventable adverse drug events in hospitalized patients: a comparative study of intensive care and general care units. *Crit Care Med* 1997;25:1289–1297.
 38. Bates DW, Kuperman GJ, Jha A, Teich JM, Orav EJ, Ma'luf N, Onderdonk A, Pugatch R, Wybenga D, Winkelman J, Brennan TA, Komaroff AL, Tanasijevic MJ. Does the computerized display of charges affect inpatient ancillary test utilization? *Arch Intern Med* 1997;157:2501–2508.
 40. Bates DW, Boyle DL, Rittenberg E, Kuperman GJ, Ma'Luf N, Menkin V, Winkelman JW, Tanasijevic MJ. What proportion of common diagnostic tests appear redundant? *Am J Med* 1998;104:361–368.
 42. Kuperman GJ, Boyle D, Jha A, Rittenberg E, Ma'Luf N, Tanasijevic MJ, Teich JM, Winkelman J, Bates DW. How promptly are inpatients treated for critical laboratory results? *J Am Med Inform Assoc* 1998;5:112–119.
 43. Jha AK, Kuperman GJ, Teich JM, Leape L, Shea B, Rittenberg E, Burdick E, Seger DL, Vander Vliet M, Bates DW. Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report. *J Am Med Inform Assoc* 1998;5:305–314.
 47. Shojania KG, Yokoe D, Platt R, Fiskio J, Ma'luf N, Bates DW. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5:554–562.
 48. Jha AK, Kuperman GJ, Rittenberg E, Bates DW. Gender and utilization of ancillary services. *J Gen Intern Med* 1998;13:476–481.
 50. Bates DW, Leape LL, Cullen DJ, Laird N, Petersen LA, Teich JM, Burdick E, Hickey M, Kleeffeld S, Shea B, Vander Vliet M, Seger D. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA* 1998;280:1311–1316.
 52. Bates DW, Kuperman GJ, Rittenberg E, Teich JM, Fiskio J, Ma'luf N, Onderdonk A, Wybenga D, Winkelman J, Brennan TA, Komaroff AL, Tanasijevic M. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106:144–150.
 53. Cañas F, Tanasijevic MJ, Ma'luf N, Bates DW. Evaluating the appropriateness of digoxin level monitoring. *Arch Intern Med* 1999;159:363–368.
 57. Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, Boyle D, Leape L. The impact of computerized physician order entry on medication error prevention. *J Am Med Inform Assoc* 1999;6:313–321.
 59. Leape LL, Cullen DJ, Clapp MD, Burdick E, Demonaco HJ, Erickson JI, Bates DW. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. *JAMA* 1999;282:267–270.
 60. Kuperman GJ, Teich JM, Tanasijevic MJ, Ma'Luf N, Rittenberg E, Jha A, Fiskio J, Winkelman J, Bates DW. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6:512–522.
 63. Bates DW, Miller EB, Cullen DJ, Burdick L, Williams L, Laird N, Petersen LA, Small SD, Sweitzer BJ, Vander Vliet M, Leape LL. Patient risk factors for adverse drug events in hospitalized patients. ADE Prevention Study Group. *Arch Intern Med* 1999;159:2553–2560.
 66. Katz JN, Solomon DH, Schaffer JL, Horsky J, Burdick E, Bates DW. Outcomes of care and resource utilization among patients with knee or shoulder disorders treated by general internists, rheumatologists, or orthopedic surgeons. *Am J Med* 2000;108:28–35.
 67. Poteat HT, Chen P, Loughlin KR, Winkelman JW, Allada R, Ma'luf N, Tanasijevic MJ, Bates DW. Appropriateness of prostate-specific antigen testing. *Am J Clin Pathol* 2000;113:421–428.
 68. Gandhi TK, Burstin HR, Cook EF, Puopolo AL, Haas JS, Brennan TA, Bates DW. Drug complications in outpatients. *J Gen Intern Med* 2000;15:149–154.
 71. Fortescue EB, Kahn K, Bates DW. Prediction rules for complications in coronary bypass surgery: a comparison and methodological critique. *Med Care* 2000;38:820–835.
 73. Gurwitz JH, Field TS, Avorn J, McCormick D, Jain S, Eckler M, Benser M, Edmondson AC, Bates DW. Incidence and preventability of adverse drug events in nursing homes. *Am J Med* 2000;109:87–94.
 74. Gandhi TK, Sittig DF, Franklin M, Sussman AJ, Fairchild DG, Bates DW. Communication breakdown in the outpatient referral process. *J Gen Intern Med* 2000;15:626–631.
 76. Ash AS, Ellis RP, Pope GC, Ayanian JZ, Bates DW, Burstin H, Iezzoni LI, MacKay E, Yu W. Using diagnoses to describe populations and predict costs. *Health Care Financ Rev* 2000;21:7–28.
 77. Teich TM, Merchia PR, Schmitz JL, Kuperman GJ, Spurr CD, Bates DW. Effects of computerized physician order entry on prescribing practices. *Arch Intern Med* 2000;160:2741–2747.
 82. Abookire SA, Karson AS, Fiskio J, Bates DW. Use and monitoring of “statin” lipid-lowering drugs compared with guidelines. *Arch Intern Med* 2001;161:53–58.
 84. Rothschild JM, Khorasani R, Silverman SG, Hanson RW, Fiskio JM, Bates DW. Abdominal cross-sectional imaging for inpatients with abnormal liver function test results: yield and usefulness. *Arch Intern Med* 2001;161:583–588.
 85. Bates DW, Su L, Yu DT, Chertow GM, Seger DL, Gomes DRJ, Dasbach EJ, Platt R. Mortality and costs of acute renal failure associated with amphotericin B therapy. *Clin Infect Dis* 2001;32:686–693.
 86. Honigman B, Light P, Pulling RM, Bates DW. A computerized method for identifying incidents associated with adverse drug events in outpatients. *Int J Med Inform* 2001;61:21–32.
 87. Kaushal R, Bates DW, Landrigan C, McKenna KJ, Clapp MD, Federico F, Goldmann DA. Medication errors and adverse drug events in pediatric inpatients. *JAMA* 2001;285:2114–2120.
 88. Honigman B, Lee J, Rothschild J, Light P, Pulling RM, Yu T, Bates DW. Using computerized data to identify adverse drug events in outpatients. *J Am Med Inform Assoc* 2001;8:254–266.
 91. Field TS, Gurwitz JH, Avorn J, McCormick D, Jain S, Eckler M, Benser M, Bates DW. Risk factors for adverse drug events among nursing home residents. *Arch Intern Med* 2001;161:1629–1634.
 92. Chertow GM, Lee J, Kuperman GJ, Burdick E, Horsky J, Seger DL, Lee R, Mekala A, Song J, Komaroff AL, Bates DW. Guided medication dosing for inpatients with renal insufficiency. *JAMA* 2001;286:2839–2844.
 93. Barsky AJ, Ettner SL, Horsky J, Bates DW. Resource utilization of patients with hypochondriacal health anxiety and somatization. *Med Care* 2001;39:705–715.
 95. Maviglia SM, Teich JM, Fiskio J, Bates DW. Using an electronic medical record to identify opportunities to improve compliance with cholesterol guidelines. *J Gen Intern Med* 2001;16:531–537.
 96. Shu K, Boyle D, Spurr C, Horsky J, Heiman H, O'Connor P, Lepore J, Bates DW. Comparison of time spent writing orders on paper with computerized physician order entry. In Patel VL, Rogers R, Haux R, ed. *MEDINFO 2001. Proceedings of the 10th World Congress on Medical Informatics, Sep 2–5, London, UK*. Amsterdam: IOS Press, 2001:1207–1211.
 97. Solomon DH, Bates DW, Schaffer JL, Horsky J, Burdick E, Katz JN. Referrals for musculoskeletal disorders: patterns, predictors, and outcomes. *J Rheumatol* 2001;28:2090–2095.
 100. Fairchild DG, McLoughlin KS, Gharib S, Horsky J, Portnow M, Richter J, Gagliano N, Bates DW. Productivity, quality, and patient satisfaction. Comparison of part-time and full-time primary care physicians. *J Gen Intern Med* 2001;16:663–667.
 101. Fortescue EB, Kahn K, Bates DW. Development and validation of a clinical prediction rule for major adverse outcomes in coronary bypass grafting. *Am J Cardiol* 2001;88:1251–1258.

105. Fairchild DG, Hogan J, Smith R, Portnow M, Bates DW. Survey of primary care physicians and home care clinicians. *J Gen Intern Med* 2002;17:253–257.
107. Poon EG, Kuperman GJ, Fiskio J, Bates DW. Real-time notification of laboratory data requested by users through alphanumeric pagers. *J Am Med Inform Assoc* 2002;9:217–222.
108. Rothschild JM, Lee TH, Bae T, Bates DW. Clinician use of a palmtop drug reference guide. *J Am Med Inform Assoc* 2002;9:223–229.
109. Doolan DF, Bates DW. Computerized physician order entry systems in hospitals: mandates and incentives. *Health Aff* 2002;21:180–188.
110. Barker KN, Flynn EA, Pepper GA, Bates DW, Mikeal RL. Medication errors observed in 36 health care facilities. *Arch Intern Med* 2002;162:1897–1903.
113. Rothschild JM, Federico FA, Gandhi TK, Kaushal R, Williams DH, Bates DW. Analysis of medication-related malpractice claims: causes, preventability, and costs. *Arch Intern Med* 2002;162:2414–2420.
114. Doolan DF, Bates DW, James BC. The use of computers for clinical care: a case series of advanced U.S. sites. *J Am Med Inform Assoc* 2003;10:94–107.
117. Forster AJ, Murff HJ, Peterson JF, Gandhi TK, Bates DW. The incidence and severity of adverse events affecting patients after discharge from the hospital. *Ann Intern Med* 2003;138:161–167.
118. Fortescue EB, Kahn K, Bates DW. Major adverse outcomes after percutaneous transluminal coronary angioplasty: a clinical prediction rule. *J Clin Epidemiol* 2003;56:17–27.
120. Maviglia SM, Zielstorff RD, Paterno M, Teich JM, Bates DW, Kuperman GJ. Automating complex guidelines for chronic disease: lessons learned. *J Am Med Inform Assoc* 2003;10:154–165.
121. Gurwitz JH, Field TS, Harrold LR, Rothschild J, DeBellis K, Seger AC, Cadoret C, Fish LS, Garber L, Kelleher M, Bates DW. Incidence and preventability of adverse drug events among older persons in the ambulatory setting. *JAMA* 2003;289:1107–1116.
122. Shapiro NI, Wolfe RE, Moore RB, Smith E, Burdick E, Bates DW. Mortality in emergency department sepsis (MEDS) score: a prospectively derived and validated clinical prediction rule. *Crit Care Med* 2003;31:670–675.
123. Chen P, Tanasijevic MJ, Schoenenberger RA, Fiskio J, Kuperman GJ, Bates DW. A computer-based intervention for improving the appropriateness of antiepileptic drug level monitoring. *Am J Clin Pathol* 2003;119:432–438.
125. Fortescue EB, Kaushal R, Landrigan CP, McKenna KJ, Clapp MD, Federico F, Goldmann DA, Bates DW. Prioritizing strategies for preventing medication errors and adverse drug events in pediatric inpatients. *Pediatrics* 2003;111:722–729.
126. Gandhi TK, Weingart SN, Borus J, Seger AC, Peterson J, Burdick E, Seger DL, Shu K, Federico F, Leape LL, Bates DW. Adverse drug events in ambulatory care. *N Engl J Med* 2003;348:1556–1564.
128. Wang SJ, Middleton B, Prosser LA, Bardon CG, Spurr CD, Carchidi PJ, Kittler AF, Goldszer RC, Fairchild DG, Sussman AJ, Kuperman GJ, Bates DW. A cost-benefit analysis of electronic medical records in primary care. *Am J Med* 2003;114:397–403.
133. Stelfox HT, Bates DW, Redelmeier DA. Safety of patients isolated for infection control. *JAMA* 2003;290:1899–1905.
134. Murff HJ, Gandhi TK, Karson AK, Mort EA, Poon EG, Wang SJ, Fairchild DG, Bates DW. Primary care physician attitudes concerning follow-up of abnormal test results and ambulatory decision support systems. *Int J Med Inform* 2003;71:137–149.
135. Bates DW, Kuperman GJ, Wang S, Gandhi T, Kittler A, Volk L, Spurr C, Khorasani R, Tanasijevic M, Middleton B. Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality. *J Am Med Inform Assoc* 2003;10:523–530.
139. Murff HJ, Forster AJ, Peterson JF, Fiskio JM, Heiman HL, Bates DW. Electronically screening discharge summaries for adverse medical events. *J Am Med Inform Assoc* 2003;10:339–350.
143. Wang SJ, Bates DW, Chueh HC, Karson AS, Maviglia SM, Greim JA, Frost JP, Kuperman GJ. Automated coded ambulatory problem lists: evaluation of a vocabulary and a data entry tool. *Int J Med Inform* 2003;72:17–28.
144. Stelfox HT, Ahmed SB, Fiskio J, Bates DW. Monitoring amiodarone's toxicities: recommendations, evidence, and clinical practice. *Clin Pharmacol Ther* 2004;75:110–122.
148. Keating NL, Gandhi TK, Orav EJ, Bates DW, Ayanian JZ. Patient characteristics and experiences associated with trust in specialist physicians. *Arch Intern Med* 2004;164:1015–1020.
150. Morimoto T, Gandhi TK, Fiskio JM, Seger AC, So JW, Cook EF, Fukui T, Bates DW. Development and validation of a clinical prediction rule for angiotensin-converting enzyme inhibitor-induced cough. *J Gen Intern Med* 2004;19:684–691.
151. Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. *Health Aff* 2004;23:184–190.
152. Yasnoff WA, Humphreys BL, Overhage JM, Detmer DE, Brennan PF, Morris RW, Middleton B, Bates DW, Fanning JP. A consensus action agenda for achieving the national health information infrastructure. *J Am Med Inform Assoc* 2004;11:332–338.
154. Field TS, Gurwitz JH, Harrold LR, Rothschild J, DeBellis KR, Seger AC, Auger JC, Garber LA, Cadoret C, Fish LS, Garber LD, Kelleher M, Bates DW. Risk factors for adverse drug events among older adults in the ambulatory setting. *J Am Geriatr Soc* 2004;52:1349–1354.
156. Heiman H, Bates DW, Fairchild D, Shaykevich S, Lehmann LS. Improving completion of advance directives in the primary care setting: a randomized controlled trial. *Am J Med* 2004;117:318–324.
162. Hsieh TC, Kuperman GJ, Jaggi T, Hojnowski-Diaz P, Fiskio J, Williams DH, Bates DW, Gandhi TK. Characteristics and consequences of drug allergy alert overrides in a computerized physician order entry system. *J Am Med Inform Assoc* 2004;11:482–491.
166. Poon EG, Gandhi TK, Sequist TD, Murff HJ, Karson AS, Bates DW. "I wish I had seen this test result earlier!": dissatisfaction with test result management systems in primary care. *Arch Intern Med* 2004;164:2223–2228.
167. Field TS, Gurwitz JH, Harrold LR, Rothschild JM, DeBellis K, Seger AC, Fish LS, Garber L, Kelleher M, Bates DW. Strategies for detecting adverse drug events among older persons in the ambulatory setting. *J Am Med Inform Assoc* 2004;11:492–498.
169. Solomon DH, Brookhart MA, Gandhi TK, Karson A, Gharib S, Orav EJ, Shaykevich S, Licari A, Cabral D, Bates DW. Adherence with osteoporosis practice guidelines: a multilevel analysis of patient, physician, and practice setting characteristics. *Am J Med* 2004;117:919–924.