Applied Strategies for Improving Patient Safety: A Comprehensive Process To Improve Care in Rural and Frontier Communities

John M. Westfall, MD, MPH; Douglas H. Fernald, MA; Elizabeth W. Staton, MSTC; Rebecca VanVorst, BA; David West, PhD; and Wilson D. Pace, MD

ABSTRACT: ***Context:*** *Medical errors and patient safety have gained increasing attention throughout all areas of medical care. Understanding patient safety in rural settings is crucial for improving care in rural communities.* ***Purpose:*** *To describe a system to decrease medical errors and improve care in rural and frontier primary care offices.* ***Methods:*** *Applied Strategies for Improving Patient Safety (ASIPS) was a demonstration project designed to collect and analyze medical error reports and use these reports to develop and implement interventions aimed at decreasing errors. ASIPS participants were clinicians and staff in 2 practice-based research networks: the Colorado Research Network (CaReNet) and the High Plains Research Network (HPRN). This paper describes ASIPS in HPRN.* ***Findings:*** *Fourteen HPRN practices with a total of 150 clinicians and staff have participated in ASIPS. Participants have submitted 128 reports. Diagnostic tests were involved in 26% of events; medication errors appeared in 20% of events. Communication errors were reported in 72%. Two learning groups developed "Principles for Process Improvement" for medication errors and diagnostic testing errors. Several safety "alerts" were issued to improve care, and 2 interventions were implemented to decrease errors.* ***Conclusions:*** *A safe and secure reporting system that relies on voluntary reporting from clinicians and staff can be successfully implemented in rural primary care settings. Information from reports can be used to identify processes that can be improved.*

Alarming reports of high incidence and mortality related to medical errors in the United States[1,2] have recently increased funding for patient safety research. Though quality of medical care has long been a topic of interest in medicine, the focus on medical errors has been much more recent. Medical errors and the threats to patient safety they represent result more from systemic conditions and characteristics of the medical setting than from the negligence or "fault" of the provider.[3,4]

Most studies of medical errors focus on those that occur in hospitals; however, a few studies directly address medical errors in outpatient settings.[5-8] Studies of patient safety in primary care suggest that errors in this setting may have serious consequences.[9,10] The few published studies of errors in rural/frontier communities focused on a single type of error[11,12] or the hospital and ER settings.[13,14]

Error reporting systems have been recommended as an integral strategy to increase patient safety and reduce errors.[1,15] The authors sought to (1) develop a patient safety reporting system in rural ambulatory primary care settings that physicians and staff would use and (2) develop clinical interventions to decrease medical errors and improve quality of care.

Methods

Applied Strategies for Improving Patient Safety (ASIPS) was 1 of 24 Agency for Healthcare Research and Quality (AHRQ)-funded 3-year demonstration projects designed to collect and analyze medical error reports[16]

Department of Family Medicine, University of Colorado Health Sciences Center, Aurora, Colo.

Supported in part by AHRQ grant 5U18HS011878-02 (W. D. P.).
For further information, contact: John M. Westfall, MD, MPH, University of Colorado Health Sciences Center, UCHSC at Fitzsimons, PO Box 6508 - Mail Stop F496, Aurora, CO 80045-0508; e-mail jack.westfall@uchsc.edu.

Table 1. Role of Person Making the Report

Role of Reporter	Number of Reports (N = 128)	Percent or Total (%)
Billing/administrative staff	2	2
Front office staff	1	1
Physician, NP, PA	91	71
RN, LPN, MA, Lab Tech	30	23
Other	4	3
Total	128	100

and 1 of 4 projects focused on primary care. ASIPS was conducted in 2 practice-based research networks: the Colorado Research Network (CaReNet) and the High Plains Research Network (HPRN). The purpose of this paper is to describe ASIPS in rural/frontier regions of Colorado among participants of the HPRN.

High Plains Research Network. HPRN is an integrated practice-based research network that consists of the medical practices in 14 communities located in rural/frontier northeast Colorado. There are 16 family practices with approximately 60 family physicians, 3 internists, 8 nurse practitioners, and 8 physician assistants. The 11 hospitals of the HPRN have 6 to 40 beds, for a total of 175 hospital beds. The closest tertiary care center is 50 to 180 miles from HPRN sites. HPRN is unique in that it represents an integrated network of all sites of practice for HPRN clinicians. The clinicians in HPRN staff the ambulatory clinics, hospitals, emergency rooms, nursing homes, and home health agencies. HPRN patients are a diverse, underserved, rural, and frontier population. The 15,000-square-mile northeast region of Colorado is largely agricultural, with a population of approximately 90,000.

Applied Strategies for Improving Patient Safety. ASIPS was a multi-institutional, practice-based project designed to collect, categorize, and analyze data on medical errors occurring in primary care offices and to develop interventions to reduce errors. The protocol was approved by the Colorado Multiple Institutional Review Board (COMIRB) and other local and regional IRBs as needed. The entire ASIPS project included (1) primary data collection and analysis from medical errors reported to a voluntary error reporting system, (2) analysis of data from secondary sources, such as insurance claims, (3) educational feedback to practices, and (4) implementation of interventions to improve patient safety. The authors currently are analyzing much of the secondary data; thus, those findings are not reported here.

Reporting System. The core of the ASIPS patient safety reporting system (PSRS) was a Web-based data collection and data management system. The ASIPS PSRS was modeled after the FAA's Aviation Safety Reporting System operated by NASA,[17] considered an excellent model for safety reporting systems in health care.[1,18] The ASIPS research team was not directly related to any institutional quality improvement group nor was any team member in a supervisory position over those making reports.

The authors encouraged wide participation from all clinical and nonclinical personnel, assuming that anyone working in a practice may observe patient safety events. This approach differs from most primary care patient safety studies, which only obtained physicians' perspectives.[9,19] The ASIPS team visited participating ambulatory offices to introduce the project to providers and staff. The team gave a brief presentation about patient safety and medical errors. It was felt that office staff might be reluctant to report events if the physicians in the office were not supportive. Thus, the physicians were asked to openly voice their support of this project so that staff understood that they were encouraged to report without fearing repercussions. Because each participating office worked with the HPRN on other research activities, each practice had a provider or staff member who coordinated HPRN research activities. ASIPS staff regularly followed up with these people to identify any problems encountered and to encourage reporting. ASIPS staff visited offices every 2 to 4 months to restock a display of paper reporting forms, talk with staff and providers, and encourage reporting.

Reporting Events. Participants were asked to report "any event you don't wish to have happen again that might represent a threat to patient safety." This broad definition was used to allow freedom to interpret what a safety event is, and is similar to the definition used in another primary care patient safety study.[9] It was explained to participants that this definition includes events associated with clinical judgment and knowledge, administrative procedures, and threats from close calls and near misses where no patient harm occurred.

ASIPS participants submitted confidential or anonymous reports by toll-free telephone hotline, secure Web site, or paper. All reporting options were equally available to participants. Participants could submit reports from anywhere, not necessarily the office where the event occurred. Neither type of report asked for any protected health information that might identify the patient(s) involved or practice-specific information that might identify the practice where the event occurred. ASIPS staff immediately removed any identifying information inadvertently included in reports.

Table 2. Examples of Patient Safety Reports from the High Plains Research Network in Applied Strategies for Improving Patient Safety

Brief Event Description	Reporter Role in Practice	Report Mechanism	Event Narrative*
X-ray labeled incorrectly	Nursing staff†	Paper - confidential	Left hip X-ray ordered by MD. Entire pelvis was shot so right and left hip were visible. After film developed, MD questioned if film labeled correctly because the abnormality was seen on the X-ray and did not correspond to the side that the patient was complaining about. X-ray got shot again. Second view labeled the same as the first. MD stated: "What are the chances both films are labeled wrong?" MD decided X-ray finding was on right hip and discharged Pt. Advised MD I could not be positive films labeled correctly and would like to re-X-ray. Pt. re-X-rayed [still in clinic, didn't have to come back]. Films indeed labeled incorrectly, Pt. and MD changed discharge instructions for Tx of fracture. [The reporter feels this was totally her fault. She was distracted because she was talking to the patient and the patient was laying in an unusual position for the X-ray, relabeled the films the second time incorrectly as well.]
Lab report in the wrong chart	Provider‡	Web - anonymous	Looking through a patient chart at the lab section and found 2 lab sheets from a different patient. I told the patient he had abnormal liver tests then saw that there was another set of labs from the next day that were normal. I investigated more closely and saw that it was a different patient with a completely different name. That lab sheet had been signed off that the patient had been notified.
Allergy injection unrefrigerated	Billing or administrative staff	Paper - confidential	(1) Patient was given his allergy injections on a Friday evening. The nurses inadvertently placed the serum [box of personalized vials] on the lab counter where it was easily seen [box was rectangular and got pushed back on the counter near books where it was somewhat hidden] – it was left out unrefrigerated over the weekend. (2) Allergist was called regarding viability of serum. The allergist did not return call before patient showed on Tuesday for another shot. [Reporter did not know at time of interview whether the nurse had ever heard back from allergist so didn't know about viability of serum.] Patient could not be seen.

* Narratives are verbatim reports and are unedited, except for removal of names and any other identifying information. Text in square brackets [ ] was added based on follow-up interviews.
† Includes lab technicians as well as registered nurses, licensed practical nurses, and medical assistants.
‡ Physician, nurse practitioner or physician assistant.

Table 3. General Type of Patient Safety Event Reported

General Type of Event	Number of Reports (N = 97)	Percent (%)
Medication event	19	20
Diagnostic testing or lab event	16	17
Delay in care (testing or treatment)	32	33
Communication event	70	72

Therefore, even in small, rural practices, the identities of reporters were protected. Full discussion of the issues related to assuring anonymity in a computerized database can be found elsewhere.[20]

The anonymous report form included 11 multiple choice items and 6 open-ended questions about the event and the people involved. Anonymous reports asked no identifying information but did ask whether the report was from a rural or urban office. The much shorter confidential report asked for the reporter's name, telephone number, and a brief description of the event. If needed, follow-up interviews were scheduled within 10 days to obtain additional information concerning the event. Confidential reports did not require follow-up if the review team determined there was sufficient information in the original report or if the event was not relevant to ASIPS (such as events that occurred entirely in inpatient settings). If it was decided not to follow up on a particular event or after the follow-up was completed, the contact information was deleted immediately. In all cases, contact information was automatically erased from the database within 10 days of the original submission. Most follow-up interviews took 5 to 15 minutes to complete, depending on the complexity of the event. Practices (not individual reporters) were paid $50 for each follow-up interview to offset the cost of time taken.

Managing Data. All reports were stored in a secure, encrypted database and managed through a Web interface, described elsewhere.[20] Data from confidential report interviews were entered directly into the database. Members of the research team, including at least 1 physician, screened all event reports and interview data for appropriateness to ASIPS. The team then assigned taxonomic codes to each report to facilitate further analysis.

Analysis of Reported Events. A multiaxial taxonomy of medical errors, Dimensions of Medical Outcomes (DMO), was used to code events.[21] This taxonomy contains 10 axes within 5 domains: patient characteristics, participants, course of events, outcome, and event discovery. In addition, the taxonomy is arranged hierarchically by subaxes within axes. The goal in using the DMO taxonomy was to provide a robust description of each patient safety report, including all process steps, associated diagnoses, associated tests, associated medications, all participants, the outcome, and the person(s) who discovered the event.

For the entire ASIPS project (rural and urban practices), the taxonomy based on the first 357 reports was modified to better describe primary care errors. Both the original taxonomy and the ASIPS modified version are available on the Web for review (www.cudfm.org/carenet/asips/taxonomy). The result was a hierarchical taxonomy that groups errors by process and clinical activity at a fine gradation and allows for easy grouping by process across various types of clinical activities or by clinical activity across various types of processes. More information about the use and development of the taxonomy is available elsewhere.[22]

The original 357 cases and all subsequent reports were recoded with the ASIPS version of the taxonomy by a team of 3 ASIPS researchers including at least 1 physician. Team members rotated between coding groups to decrease coding bias. Codes assigned to reports were determined by consensus.

Relevance to Actual Clinical Practice. Two specific groups provided guidance and advice to ASIPS.

Clinical Steering Committee. A Clinical Steering Committee (CSC) was created, composed of 12 physicians and staff members from participating clinical sites, 2 representatives from malpractice insurance providers, and the chief medical officer of the Colorado State Department of Health and Environment. The group met regularly to review data, direct additional study, and create policy.

Learning Groups. A series of "learning groups" met to assist project staff and the CSC. Learning group members included physicians and staff from participating clinics who had particular interest and expertise in patient safety. Each learning group tackled a different patient safety issue selected by the CSC, based on information in the ASIPS reporting system. The study coordinator and an experienced researcher supported the work of the learning groups by scheduling and facilitating meetings, keeping and distributing meeting minutes, providing background material, assisting with between-meeting "assignments," and drafting reports of the group's work and recommendations. Other experts, such as a Web developer and a doctor of pharmacy, supported the groups as needed.

Learning groups were asked to identify an approach to understanding and interpreting the

error data, describe "Principles for Process Improvement" (PPI) for a given error type, and develop possible interventions for improving care. The learning groups were often lively debates as clinicians, staff, and researchers struggled with developing principles for improving practice. Because of the geographic distribution of members, getting members together was difficult. Conference calls and e-mail were relied on to improve communication.

Educational Feedback. When ASIPS identified serious threats to patient safety, electronic and hard-copy "alerts" were issued to all participants. Each alert briefly described the patient safety event and recommendations developed by the ASIPS team for decreasing the potential for that type of event. This approach is similar to the Federal Aviation Administration's "alerting messages," which are broadcast when a report is received about a potential hazard that may be corrected.[23] Additional feedback to practices included a periodic newsletter and practice-specific suggestions for general improvement in patient safety.

Results

The authors enrolled 14 rural or frontier practices with 150 clinicians and staff who consented to participate. As of February 2004, the ASIPS patient safety reporting system has received over 800 reports, 128 of which were from rural or frontier practices. Forty-six percent of reports from rural sites were submitted using the confidential form. Of all reports, 2% were reported by telephone, 50% by Web, and 48% by paper. Table 1 shows the role of the reporter. Providers (physicians, nurse practitioners, physician assistants) were more likely to report using the anonymous system (75%), whereas nurses and other office staff were more likely to report using the confidential system (81%) ($P<.001$).

Ninety-seven of the 128 reports submitted by rural or frontier sites were coded. Table 2 provides several examples of reports. An event participant was defined as someone who was involved in the event at the time the event occurred (including patients when their conscious action or inaction contributed to the event). Of the 83 reports for which types of participants could be identified, 51% involved a provider, 46% involved another licensed clinician (eg, registered nurse, licensed practical nurse, medical assistant, radiology technician), 21% involved a nonlicensed caregiver or office staff, 15% involved a patient or someone related to the patient, and 33% involved a third party (eg, a payer, a supplier, a regulatory or government body, or another health care facility). These figures add up to more than 100%, indicating many events involved more than 1 type of participant. In fact, 49% involved 2 participants and 10% involved 3 to 4 participants.

Table 3 presents data on the nature of reported events from rural practices. Overall, the data reveal the prominence of errors associated with diagnostic tests (eg, lab tests, imaging, cytology, pathology, and stress tests), medication errors (eg, wrong drug, right drug but wrong dose or form, delay in prescribing), delays in care, and communication errors. Further description and analysis of the full ASIPS dataset is reported elsewhere.[24]

Interventions Planned or Implemented. With the assistance of the Clinical Steering Committee, 2 areas for possible practice-level intervention were identified: laboratory errors and prescription errors. The learning groups developed "Principles for Process Improvement" (PPIs) for each identified area. By design, these PPIs were not specific to individuals but focused on office processes amenable to assessment and improvement. Both PPIs led to interventions that involved the use of information technology to reduce the frequency of errors and to immediately identify errors, if and when they occur. Evaluation of these interventions is ongoing. A full description of the learning groups and the development of PPIs is found elsewhere.[25]

Based on the PPI for diagnostic testing, the authors developed and implemented an automated "lab tracker" system that has the following features: tracks all lab tests ordered by the practice and returned to the practice, calculates a due date for lab results to be returned to the practice, provides automated reports daily to inform practice personnel of overdue tests, and incorporates features for the special tracking of high priority tests and alarm values. Based on the PPI for prescription writing, several practices adopted the use of a modified commercially available computerized physician order entry prescription system. The system writes a prescription, checks for possible contraindications using the Micromedex database, assures that scripts include the indication in plain English, allows for easy updating and printing of accurate medication lists, and transmits the prescription electronically directly to a pharmacy.

Alerts. Several serious threats to patient safety were identified and electronic and hard-copy alerts were issued. Alerts to date have addressed issues such as adult patients receiving pediatric doses of immunizations, errors related to computerized "autofill" systems, and laboratory failure to highlight abnormal glucose levels (the alerts themselves can be found on the Internet at www.cudfm.org/carenet/asips/default.asp).

An example of an issue alert relates to a common lab test. Many laboratories do not consider abnormal D-dimer test results critical values, so they do not immediately notify clinicians of these results. Several ASIPS reports indicated that D-dimers were ordered to evaluate suspected deep vein thrombosis or pulmonary embolus, but the results were not recognized and dealt with by clinicians for up to 96 hours. In some cases, the laboratory ignored a specific request to notify the ordering physician via pager. Through the alert, it was recommended that after-hours D-dimer results be obtained by the provider as soon as available from the lab and discussed with the patient. The local hospitals and reference laboratories were encouraged to evaluate their notification protocols for this increasingly common test.

Discussion

A system to make reporting medical errors easy, safe, and reliable for rural/frontier primary care providers and staff has successfully been implemented. Of note, this approach also results in interventions designed to reduce error, which are based on both actual error reports and the knowledge and experience of practicing physicians and staff. The ASIPS Clinical Steering Committee and learning groups provided forums for medical providers and staff to be involved in interpreting the results, developing guiding principles of practice, and implementing interventions aimed at improving care. The interventions were based on actual ambulatory care office practice, and rural office staff were actively involved in implementation, an approach that differs from most previous studies of patient safety in primary care, which relied only on physician reporting.[19] The ASIPS approach successfully brings together a university research team and community clinicians and office staff to collaborate and improve patient care.

Like other studies,[26] it was found that communication breakdowns appear to be involved in many errors, yet they are not frequently reported as the major component of the event. The contribution of communication breakdowns may not be reflected in coding systems that group events in single general categories.[9,27] The ASIPS taxonomy provides both a simple look at types of errors (medication, lab, and so forth) and a more robust analysis of causes (communication between consultant and physician, poor system for tracking lab tests, and so forth). The ability to examine errors and causes of errors in such a manner highlights the value of a hierarchical and multiaxial approach to coding errors.[28,29]

Though more than 150 rural clinicians and office staff consented to participate in the study, only 128 reports were received from rural sites. It may be that some reporters did not identify their office as rural when they made their report and hence were not included in the final analysis. However, it is also likely that many potential participants did not make a report. Though all office staff were encouraged to report events, if may be that many staff did not notice a patient safety event, were not comfortable with the reporting mechanisms, or were uncomfortable making a "bad" report about their office. Reporting systems generally underestimate the occurrence of errors,[1,30] and other researchers have found a high degree of variability in the number of reports made from primary care settings.[9,10,26] In one of the earliest studies of primary care errors, 324 Australian physicians agreed to participate in error reporting, but 83 (26%) did not submit even 1 report.[26] Similarly, in another primary care study, 12 of 54 (22%) physicians who agreed to report did not report any errors.[9] Due to the nature of the ASIPS anonymous and confidential reporting system, there is no way to know how many individuals made the 128 reports. It is possible that many reports made to ASIPS were from a small proportion of participants. Unlike previous primary care error reporting projects,[9,10,26] the practices participating in ASIPS were not selected due to high interest in medical errors or from interested volunteers but were approached because they cared for patients in a specific geographic region. Thus, it is not surprising that many members of HPRN practices were likely not enthusiastic reporters.

Though non-physicians accounted for just one quarter of the submitted reports, it is believed that their involvement enhanced the practice-wide culture of safety. Clinicians may not have wanted to admit and report a "bad" event or outcome. Anecdotally, some providers disclosed that they were too busy to make a report when it was identified and then forgot to make the report later. More contact between the research team and the office staff may increase reporting. Identifying a physician leader in each office who can regularly encourage other providers and staff to recognize events and make timely reports may increase the number of reports in future projects. A report on the beliefs and attitudes toward patient safety of the ASIPS participants is beyond the scope of this paper, but the ASIPS research team is working on a paper describing attitudes.

The interventions designed by the learning groups both involved information technology (IT) "solutions" to the identified problems. Though IT has been hailed as the solution for patient safety issues,[31,32] IT can *cause* errors.[33] For example, reports to ASIPS indicated that the "auto-fill" capability of computers has led to errors. Thus, as others have found,[34] technology solutions are not perfect. To address these concerns, the authors

believe it is important to develop IT interventions very carefully. The interventions developed by the learning groups and based on the PPIs must be carefully deployed and will require further research to determine if they, in fact, improve patient safety.

A third-party reporting and analysis system may be particularly appropriate for rural/frontier practices when linked by a practice-based research network or other collaborative process. The collaborative effect increases the number of events to be analyzed, thus improving the understanding of rural patient safety events. And, more importantly, it reduces the risk of reporters ''being found out'' when the number of staff in any single practice may be small and individual roles easily identified. Furthermore, a single practice could not undertake such a comprehensive approach involving error reporting and evaluation and practice change. A long-term sustainable version of a third-party system such as ASIPS and the ''Principles for Process Improvement'' method may be feasible and appropriate for rural medical practices and communities.

Conclusions

ASIPS brought together a university research team and rural and urban community clinicians and office staff to collaborate and improve patient care. The lessons learned from ASIPS confirm that the reporting of medical errors, and more importantly, their analysis for use in developing targeted interventions, can be achieved in rural/frontier settings. ASIPS lays the foundation for additional research into the frequency and causes of medical errors in rural practice, and it clearly demonstrates that rural practices are willing to participate in error reporting and interventions.

References

1. Kohn LT, Corrigan J, Donaldson MS, eds. *To Err Is Human: Building a Safer Health System.* Washington, D.C.: National Academy Press; 2000.
2. Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med.* 1991;324:370–376.
3. Larson EB. Measuring, monitoring, and reducing medical harm from a systems perspective: a medical director's personal reflections. *Acad Med.* 2002;77(10):993–1000.
4. Classen DC, Kilbridge PM. The roles and responsibility of physicians to improve patient safety within health care delivery systems. *Acad Med.* 2002;77:963–972.
5. Wilf-Miron R, Lewenhoff I, Benyamini Z, Aviram A. From aviation to medicine: applying concepts of aviation safety to risk management in ambulatory care. *Quality & Safety in Health Care.* 2003;12:35–39.
6. Gandhi TK, Weingart SN, Borus J, et al. Adverse drug events in ambulatory care. [comment]. *N Engl J Med.* 2003;348:1556–1564.
7. Gurwitz JH, Field TS, Harrold LR, et al. Incidence and preventability of adverse drug events among older persons in the ambulatory setting. [comment]. *JAMA.* 2003;289:1107–1116.
8. Elder NC, Dovey SM. Classification of medical errors and preventable adverse events in primary care: a synthesis of the literature.[erratum appears in J Fam Pract. 2002 Dec;51(12):1079.]. *J Fam Pract.* 2002;51:927–932.
9. Dovey SM, Meyers DS, Phillips RL Jr, et al. A preliminary taxonomy of medical errors in family practice. *Quality & Safety in Health Care.* 2002;11:233–238.
10. Makeham MA, Dovey SM, County M, Kidd MR. An international taxonomy for errors in general practice: a pilot study. *Med J Aust.* 2002;177:68–72.
11. Jemmett ME, Kendal KM, Fourre MW, Burton JH. Unrecognized misplacement of endotracheal tubes in a mixed urban to rural emergency medical services setting. *Acad Emerg Med.* 2003;10(9):961–965.
12. Taylor CT, Byrd DC, Krueger K. Improving primary care in rural Alabama with a pharmacy initiative. *Am J Health Syst Pharm.* 2003;60:1123–1129.
13. Wolff AM, Bourke J. Detecting and reducing adverse events in an Australian rural base hospital emergency department using medical record screening and review. *Emerg Med J.* 2002;19:35–40.
14. Wolff AM, Bourke J, Campbell IA, Leembruggen DW. Detecting and reducing hospital adverse events: outcomes of the Wimmera clinical risk management program. *Med J Aust.* 2001;174:621–625.
15. Doing What Counts for Patient Safety: Federal Actions to Reduce Medical Errors and their Impact. Report of the Quality Interagency Coordination Task Force to the President, February 2000. Quality Interagency Coordination Task Force, Washington, DC: Available at http://www.quic.gov/report/toc.htm. Accessed July 29, 2004.
16. Agency for Healthcare Research and Quality. Fact sheet: patient safety research initiatives-fiscal year 2001. 2001. Available at: http://www.ahrq.gov/qual/ps2001.htm #support. Accessed March 26, 2003.
17. Reynard WD, Billings CE, Cheaney ES, Hardy R. The development of the NASA Aviation Safety Reporting System. NASA Reference Publication 1114 ed. Hanover, MD: NASA Scientific and Technical Information Branch; 1986.
18. Barach P, Small SD. Reporting and preventing medical mishaps: lessons from non-medical near miss reporting systems. *BMJ.* 2000;320:759–763.
19. Dovey SM, Phillips RL, Green LA, Fryer GE. Types of medical errors commonly reported by family physicians. *Am Fam Physician.* 2003;67:697.
20. Pace WD, Staton EW, Higgins GS, Main DS, West DR, Harris DM. Database design to ensure anonymous study of medical errors: a report from the ASIPS collaborative. *J Am Med Inform Assoc.* 2003;10:531–540.
21. Victoroff MS. Dimensions of medical outcome: a taxonomy. Version 00-1204 (''Five Decimal Version''), 2000. Available at http://www.cudfm.org/carenet/asips/taxonomy. Accessed July 16, 2004.
22. Pace WD, Fernald DH, Harris D, et al. Developing and analyzing a taxonomy to code ambulatory medical errors: a report from the ASIPS Collaborative *Advances in Patient Safety: From Research to Implementation* (In Press.)
23. NASA. Aviation Safety Reporting System Web Site. Available at: http://asrs.arc.nasa.gov. Accessed May 26, 2004.
24. Fernald DH, Pace WD, Harris DM, West DR, Main DS, Westfall J. Event reporting to a primary care patient safety reporting system: A Report from the ASIPS Collaborative. *Annals of Family Medicine* 2004;2(4):327–332.
25. West D, Westfall JM, Araya-Guerra R, et al. Using reported primary care errors to develop and implement patient safety interventions:

a report from the ASIPS Collaborative. *Advances in Patient Safety: From Research to Implementation* (In Press.)
26. Bhasale AL, Miller GC, Reid SE, Britt HC. Analysing potential harm in Australian general practice: an incident-monitoring study. *Med J Aust.* 1998;169:73–76.
27. Tuttle D, Panzer RJ, Baird T. Using administrative data to improve compliance with mandatory state event reporting. *Jt Comm J Qual Improv.* 2002;28:349–358.
28. Denison A, Pierce JR Jr. Systems analysis of a clinical error. *Journal of Public Health Management & Practice.* 2003;9:43–46.
29. Reason J. Human error: models and management. *BMJ.* 2000;320:768–770.
30. Leape LL. Error in medicine. *JAMA.* 1994;272:1851–1857.
31. Bates DW, Cohen M, Leape LL, Overhage JM, Shabot MM, Sheridan T. Reducing the frequency of errors in medicine using information technology. *J Am Med Inform Assoc.* 2001;8:299–308.
32. Barber N, Rawlins M, Dean Franklin B. Reducing prescribing error: competence, control, and culture. *Qual Saf Health Care.* 2003;12:i29–i32.
33. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. *J Am Med Inform Assoc.* 2004;11:104–112.
34. Vicente KJ. Less is (sometimes) more in cognitive engineering: the role of automation technology in improving patient safety. *Qual Saf Health Care.* 2003;12:291–294.