ERROR MANAGEMENT

Ambulatory care adverse events and preventable adverse events leading to a hospital admission

Donna M Woods, Eric J Thomas, Jane L Holl, Kevin B Weiss, Troyen A Brennan

Qual Saf Health Care 2007;16:127–131. doi: 10.1136/qshc.2006.021147

See end of article for authors' affiliations

Correspondence to:
Dr D M Woods, Institute for
Healthcare Studies, Feinberg
School of Medicine,
Northwestern University,
676 Street, Clair Street,
Chicago, IL 60611 USA;
woods@northwestern.edu

Accepted 13 January 2007

Background: Most healthcare in the US is delivered in the ambulatory care setting, but the epidemiology of errors and adverse events in ambulatory care is understudied.

Methods: Using the population-based data from the Colorado and Utah Medical Practices Study, we identified adverse events that occurred in an ambulatory care setting and led to hospital admission. Proportions with 95% CIs are reported.

Results: We reviewed 14 700-hospital discharge records and found 587 adverse events of which 70 were ambulatory care adverse events (AAEs) and 31 were ambulatory care preventable adverse events (APAEs). When weighted to the general population, there were 2608 AAEs and 1296 (44.3%) APAEs in Colorado and Utah, USA, in 1992. APAEs occurred most commonly in physicians' offices (43.1%, range 46.8–27.8), the emergency department (32.3%, 46.1–18.5) and at home (13.1%, 23.1–3.1). APAEs in day surgery were less common (7.1%, 13.6–0.6) but caused the greatest harm to patients. The types of APAEs were broadly distributed among missed or delayed diagnoses (36%, 50.2–21.8), surgery (24.1%, 36.7–11.5), non-surgical procedures (14.6%, 25.0–4.2), medication (13.1%, 23.1–3.1) and therapeutic events (12.3%, 22.0–2.6). Overall, 10% of the APAEs resulted in serious permanent injury or death. The proportion of APAEs that resulted in death was 31.8% for general internal medicine, 22.5% for family practice and 16.7% for emergency medicine.

Conclusion: An estimated 75 000 hospitalisations per year are due to preventable adverse events that occur in outpatient settings in the US, resulting in 4839 serious permanent injuries and 2587 deaths.

Most healthcare in the US is delivered in the ambulatory care setting. Nearly one billion ambulatory visits are made annually to physicians' offices, emergency departments, hospital clinics and ambulatory surgery centres.¹ The number of visits to primary-care and emergency departments, and ambulatory surgeries have all increased in the past decade making ambulatory care an important setting for healthcare delivery and therefore for patient safety.² Despite the quantity of healthcare being delivered in the ambulatory care setting, patient safety in ambulatory care remains an understudied topic of research.²

Several qualitative studies have described and classified medical errors in ambulatory care,^{3–6} and previous research has found that recommended healthcare for acute and chronic conditions and preventive services was provided to only 54.9% of patients.⁷ However, the relative rates and amount of harm associated with adverse events in the ambulatory setting remains unknown. Without such fundamental information, it is difficult to prioritise the areas for quality and patient safety research, and subsequent improvement.

The epidemiology of ambulatory adverse events and the associated harm probably differs from inpatient events for several reasons. Ambulatory care is more difficult to coordinate because of the frequent use of off-site laboratory and pharmacy services and referrals to specialty services and providers. In addition, the patient in ambulatory care is often primarily responsible for coordinating his or her care, sometimes with help from family or friends. Opportunities for error and related injuries are likely to differ from those in hospital-based care, by type of ambulatory care setting, type of care (eg, diagnostic, surgery) and may differ by population (age group, ethnic or racial groups). Understanding the nature and effect of ambulatory care risks will help prioritise and direct attention towards effective targets for improvement in patient safety in ambulatory care.

We hypothesise that a substantial number of patients are harmed by preventable adverse events in the ambulatory setting. We analysed data from the Utah and Colorado Medical Practice Study⁸ to describe the frequency, types and harm associated with ambulatory care adverse events (AAEs) and ambulatory care preventable adverse events (APAEs) that led to hospitalisations. These population-based data remain unique for the study of adverse events.

METHODS

Definitions

Throughout this paper, the following definitions will be used. An adverse event is "an injury caused by medical management (rather than the disease process) that led to a hospitalisation" and a preventable adverse event is "an injury caused by medical management (rather than the disease process) that led to hospitalisation, where there was enough information currently available to have avoided the event using currently accepted practices".⁹

The Colorado and Utah Medical Practices study

This study is based on an analysis of adverse events and preventable adverse events in the Colorado and Utah Medical Practices Study that occurred in an ambulatory care setting and resulted in a hospital admission. These data enable the estimation of population-based epidemiological results.⁸

From a representative sample of hospitals in Utah and Colorado, 5000 medical records from Utah and 10 000 from Colorado were randomly selected. The number of records per hospital was proportional to the number of discharges at each

Abbreviations: AAE, ambulatory care adverse event; APAE, ambulatory care preventable adverse event; ED, emergency department

hospital relative to the total discharges of all hospitals in the study.^{8,9}

Trained-nurse reviewers first reviewed all of the sampled records using standardised criteria associated with adverse events. Then, physician reviewers graded, on a six-point confidence scale, their confidence that an adverse event had occurred. A score of ≥ 4 was required for the event to be classified as an adverse event. The reliability of the physicians' adverse-event judgments was fair (79% agreement ($\kappa = 0.4$)).⁸

A total of 587 adverse events were identified (Colorado, 418 and Utah, 169). Adverse events were classified into mutually exclusive types depicting the context of medicine (eg, medication, surgical), the types of physicians involved (eg, pediatrics, family practice, obstetrics), and the location in which the event occurred. Two study investigators then determined the preventability of the event, based on a six-point scale, according to the study definition.⁸ The reliability of preventable adverse event judgments was good ($\kappa = 0.8$).⁹ The harm associated with each event was assessed on a 0–9 scale (box 1).

This analysis only includes events where the medical management that led to the adverse event and subsequent admission to the hospital occurred in an ambulatory care setting. Ambulatory care settings, for the purposes of this study, included a physician's office, ambulatory surgery setting, the ED, a hospital clinic or the patient's home. Ambulatory care settings for surgical procedures included physician offices, ambulatory surgery settings and hospital clinics.

Analysis

The characteristics of the sample from the Colorado and Utah Medical Practices Study were compared with those of all hospital discharges in Utah and Colorado during the same time period, to assess the representativeness of the study sample.

Population estimates and frequency of ambulatory care-related adverse events and preventable adverse events were determined. The mean levels of resulting harm from the events were assessed; the proportion of ambulatory events leading to serious injury or death was estimated. Population estimates and frequencies were calculated for the type of ambulatory care setting in which the event occurred, the type of physician involved in the ambulatory care event and the age of the patients. Mean level of harm for ambulatory care events was statistically compared with the mean level of harm for inpatient-care events.

RESULTS

The demographic characteristics of the sampled discharges were similar to the characteristics of all discharges in each state. Of the 14 700 hospital discharge records reviewed, 587 (4.0%)

adverse events were identified. Of these, 70 (11.9%) adverse events and 31 (12.0%) preventable adverse events occurred in the ambulatory care setting and led to a hospital admission. When weighted to the general population, 2608 ambulatory adverse events occurred in Utah and Colorado in 1992, of which 1296 (49.7%) were preventable. All these events were of sufficient harm to result in hospital admission.

Adverse and preventable adverse events

Setting

Most AAEs that led to hospital admission occurred in physicians' offices, patients' homes and the EDs (table 1). The highest mean level of harm was associated with AAEs that occurred in a physician's office (table 1). Most preventable ambulatory adverse events occurred in physicians' offices (43.1%) and EDs (32.3%), representing 75% of all APAEs. However, the greatest mean harm was related to APAEs that occurred in ambulatory surgery (4.5) and was significantly higher than the level of harm associated with the preventable adverse events in all other ambulatory care settings.

Event types

The majority of AAEs were medication events (31.7%), surgical events (28.3%) or diagnostic adverse events (17.9%; table 2). Diagnostic adverse events led to the greatest mean harm (4.4). Preventable ambulatory adverse events were evenly distributed among the following types of care: diagnostics (36.0%), surgery (24.1%), non-surgical procedures (14.0%), medication (13.1%) and therapeutic events (12.3%). Harm associated with these preventable adverse event types was greatest in the context of surgery (4.0) and diagnostics (3.4).

Physician types

The greatest proportion, nearly one-third, of the APAEs (31.4%) involved primary care physicians (general internal medicine and family practice; table 3), followed by an even distribution across a broad range of medical and surgical specialties and emergency medicine. Pediatricians and radiologists were rarely involved in these events. The preventable adverse events attributed to primary care clinicians caused the greatest mean level of harm.

Patient characteristics

Non-elderly adults were the most frequently affected group by AAEs and preventable adverse events, followed by elderly adult patients (table 4). The location most frequently associated with preventable adverse events differed by age. Preventable adverse events in children were most frequent in a physician's office or a hospital clinic, whereas non-elderly adults most frequently experienced an adverse event in the ED. For elderly patients, preventable adverse events were more common in the ED and at home.

Female patients experienced 67% of the identified adverse events and 84% of the preventable adverse events. In all, 77% of adverse events and 84% of preventable adverse events were experienced by Caucasian patients.

Levels of harm

The mean level of harm resulting from AAEs was 3.0. The mean level of harm resulting from preventable AAEs was 3.2. No significant difference was found between the levels of harm for APAEs compared with the level of harm associated with hospital-based care events.

Overall, 10% of APAEs resulted in serious permanent injury or death. The services with the highest proportion of preventable adverse events that resulted in serious permanent

Box 1: Harm scale

Level of harm:

1. No harm
2. Emotional harm
3. Insignificant harm
4. Minor temporary harm
5. Major temporary harm
6. Minor permanent harm
7. Major permanent harm
8. Serious permanent harm
9. Grave harm
10. Death

Table 1 Estimates of ambulatory care adverse events and preventable adverse events that led to hospital admission by ambulatory care setting and level of harm

	Adverse events		Mean level of harm	Preventable adverse events		Mean level of harm
	n	% (95% CI)	Mean (95% CI)	n	% (95% CI)	Mean (95% CI)
Physician office	972	37.3 (46.8 to 27.8)	3.96 (4.13 to 3.79)	559	43.1 (57.7 to 28.5)	3.08 (3.33 to 2.83)
Emergency department	514	19.7 (27.5 to 11.9)	3.25 (3.42 to 3.08)	418	32.3 (46.1 to 18.5)	3.20 (3.45 to 2.95)
Home	611	23.4 (31.7 to 15.1)	2.90 (3.06 to 2.73)	170	13.1 (23.1 to 3.1)	3.20 (3.45 to 2.95)
Day surgery	248	9.5 (15.3 to 3.7)	2.57 (2.74 to 2.40)	92	7.1 (13.6 to 0.6)	4.50 (4.75 to 4.25)
Hospital clinic	263	10.1 (16.0 to 4.2)	2.67 (2.84 to 2.50)	57	4.4*	3.00 (3.25 to 2.75)
Ambulatory care	2608	100.0	3.01 (3.18 to 2.84)	1296	100.0	3.22 (3.47 to 2.97)

*Sample size not sufficient for estimation.

injury or death, included, general internal medicine (31.75%), family practice (22.45%) and emergency medicine (16.70%).

DISCUSSION

In Utah and Colorado in 1992, the proportion of hospital admissions due to an adverse event in ambulatory care was 0.476% resulting in 2608 AAEs. The proportion of hospital admissions resulting from a preventable adverse event in ambulatory care was 0.211% resulting in 1296 APAEs. When extrapolated to all US discharges (approximately 36 000 000 hospital discharges annually in the US) the estimated annual number of hospital admissions resulting from an adverse event in ambulatory care is 171 360. This number is higher than the total number of admissions for phlebitis, thrombophlebitis and thromboembolism, or for abdominal hernia.¹⁰ The national estimated number of annual hospital admissions resulting from preventable adverse events in ambulatory care is 75 858. Of these events, 10% led to serious permanent harm or death. Hospital-admission-related preventable adverse events in ambulatory care result in more hospital admissions than HIV infection, or cervical and uterine cancer combined.¹⁰ Of the admissions in which a preventable adverse event in an outpatient setting occurred, extrapolated nationally, this resulted in 4839 serious permanent injuries and 2587 deaths.

Not surprisingly, physician's offices and emergency rooms, the most common settings for ambulatory care, were the settings for the most (75%) preventable ambulatory adverse events. Similarly, general medicine internists and family physicians, representing nearly 30% of all US physicians,^{11 12} were the types of physicians most often involved in the occurrence of preventable events. These clinicians were involved in about one-third of the ambulatory preventable adverse events followed by an even distribution of preventable ambulatory adverse events among medical and surgical specialists and emergency medicine physicians. The types of preventable events were evenly distributed among diagnostics,

surgical and medical procedures, medication, and incorrect or delayed treatments.

These data suggest that a wide array of strategies may be needed to reduce ambulatory adverse events. An initial focus on diagnostic errors in office-based general internal medicine and family practice may be warranted. It is not surprising that the multifaceted nature of processes in primary care practice including preventive screening, diagnosis and treatment of acute and chronic problems, and health promotion activities can lead to errors that can lead to significant harm. Previous research has identified specific aspects of primary care that could lead to diagnostic errors. For example, missing clinical information is common in the coordination of the care.¹³ Appointment scheduling, chart management, and follow-up of test results are additional important steps in the coordination of the care process for which errors and related injuries are common.¹⁴ Several studies point to the challenges of laboratory testing and imaging processes in ambulatory care. Hickner *et al* reported that laboratory tests and imaging studies were ordered during 29–38% of clinical encounters and that between 15% and 54% of errors reported by office-based physicians and staff were related to these processes.¹⁵ Nutting *et al* reported that problems with laboratory testing in primary care physician offices occurred in 1.1 per 1000 patient visits¹⁶ and, that the communication of test results was also frequently problematic. Studies of clinicians' perceptions of laboratory and imaging processes have shown that most primary care clinicians are not satisfied with their methods of tracking abnormal results,¹⁷ report that delays in results are common¹⁸ and that follow-up care is suboptimal.^{15 19} In addition, although a key activity in primary care is the provision of preventive care, appropriate preventive screening was shown to occur in only 55% of the visits for which screenings were indicated.⁷

This study suggests that ambulatory care diagnostic events can result in high levels of harm. Process improvement activities to increase the reliability of tracking and communicating critical laboratory values are underway in hospital-

Table 2 Estimates of hospital-admission-related ambulatory care adverse events and preventable ambulatory adverse events by type and estimation of harm

Event type	Adverse events		Mean level of harm	Preventable adverse events		Mean level of harm
	n	% (95% CI)	Mean (95% CI)	n	% (95% CI)	Mean (95% CI)
Diagnostic	466	17.9 (25.4 to 10.4)	4.44 (4.61 to 4.27)	466	36.0 (50.2 to 21.8)	3.43 (3.68 to 3.18)
Surgical	737	28.3 (37.1 to 19.5)	3.16 (3.33 to 2.99)	312	24.1 (36.7 to 11.5)	4.03 (4.28 to 3.78)
Medication	827	31.7 (40.8 to 22.6)	3.00 (3.17 to 2.83)	170	13.1 (23.1 to 3.1)	2.57 (2.82 to 2.32)
Non-surgical procedures	222	8.5 (14.0 to 3.0)	3.33 (3.50 to 3.16)	189	14.6 (25.0 to 4.2)	2.59 (2.84 to 2.34)
Therapeutic	228	8.7 (14.2 to 3.2)	2.50 (2.67 to 2.33)	159	12.3 (22.0 to 2.6)	3.29 (3.54 to 3.04)
Fracture and falls	88	3.4 (6.4 to 0.2)	3.50 (3.67 to 3.33)	0	0.0	0.00
Anaesthesia	40	1.5*	3.00 (3.17 to 2.83)	0	0.0	0.00

*Sample size not sufficient for estimation.

Table 3 Estimates of hospital-admission-related ambulatory care preventable adverse events by type of service involved and estimation of harm

Service type	Total, n	% (95% CI)	Harm, n (95% CI)
Primary care	407	31.4 (33.5 to 29.3)	4.03 (4.28 to 3.78)
Medical specialty	282	21.8 (23.7 to 19.9)	2.51 (2.80 to 2.30)
Surgical specialty	293	22.6 (24.5 to 20.7)	2.90 (3.15 to 2.65)
Emergency medicine	239	18.5 (20.3 to 16.7)	3.08 (3.33 to 2.83)
Paediatrics	13	1.0 (1.5 to 0.05)	1.00 (1.25 to 0.75)
Radiology	58	4.5 (5.4 to 3.60)	3.00 (3.25 to 2.75)

based contexts and could potentially be applied to ambulatory care.²⁰

Medication safety is another area of importance in primary care^{21, 22} and, as shown in this study, medication-related preventable ambulatory adverse events are common. Use of technology, particularly computerised physician order entry systems, has been recommended to deal with many of the challenges of medication safety in hospital-based contexts, but such systems are not, as yet, common in ambulatory care settings. Medication reconciliation is also being recommended for ambulatory care, however, there are many additional documented medication safety risks that will remain unresolved even with effective implementation of these interventions, such as look-alike/sound-alike medications²³ and adequate patient education.²⁴ Both medication factors and patient-related factors have been shown to contribute to medication safety risks²⁴ and many older patients in this study were found to have experienced medication events in the home.

Preventable ambulatory adverse events related to surgery and other procedures comprised more than one-third of all events and resulted in the highest level of harm to patients. The frequency of such events may now be significantly higher considering that the number of ambulatory care surgeries and procedures has increased annually since 1992 (year of data collection). Currently, 60% of elective surgical procedures in the US occur in an outpatient setting.²⁵ The findings in this study also support previous findings in which hospitalisation within 7 days of an ambulatory surgery occurred in 9.08 per 1000 patients and the death rate of patients from ambulatory surgery was 35 per 100 000 patients.²⁶ Although there has been significant patient safety improvement activity in hospital-based care, relatively fewer patient safety interventions have been adopted in ambulatory care surgery and office-based contexts. Increased research and monitoring of ambulatory surgery and procedures (in both ambulatory surgery centres and physician offices) may be needed.

The Institute of Medicines report²⁷ estimated from the data used in this study that 44 000 deaths occur annually in the US that are attributable to preventable adverse events. Of these 44 000 deaths 5.50% occurred as a result of a preventable adverse event in ambulatory care settings, resulting in an estimated 2419 APAE deaths in the US annually.

IMPLICATIONS

The dispersed nature of ambulatory care settings compared with hospital-based environments makes it more difficult to study errors and to implement safety improvements. Currently, there is no established method for collecting or communicating information about errors that occur in ambulatory care settings, nor is there any systematic method for the dissemination of information about potential patient safety improvements. For example, the development of infrastructures to support the identification of safety risks and the redesign of ambulatory processes (eg, adoption of information technologies) could facilitate improved safety in these settings. Feedback and the provision of incentives for reorganisation and improvement are strategies that have been shown to have an effective impact on care practices in physician office-based settings.^{28, 29} Additionally, training in risk identification methods and support of process improvement may further facilitate effective redesign and reorganisation of office systems and practices. This lack of systems and resources to support patient safety improvements in office-based practices highlights a critical topic for healthcare policy makers. The substantial difficulties in promoting practice, system, process changes for individual practitioners or practices suggest that the implementation of strategies to reduce preventable adverse events in ambulatory care settings may be a difficult task.

Further study is needed to better understand the systemic factors that lead to risks related to diagnostics, surgical and non-surgical procedures and medication in ambulatory care settings. Additionally, research is needed to understand effective methods to improve the reliability of ambulatory care, whether it is through translation of existing hospital-based safety strategies or the design of new systems and methods customised for ambulatory care.

STRENGTHS AND LIMITATIONS

This study uses the only available and most recent data about AAEs from a population-based sample. The results are generalisable and, therefore, useful for prioritising future patient safety research in ambulatory care. However, the data are from hospitalisations in 1992 and include only those events that led to a hospital admission, and were detectable by a review of medical records. This study captures only AAEs with

Table 4 Population estimates of preventable adverse events by age group and setting

Age group	Total PAEs*, n	Ambulatory care PAEs*		Distribution of ambulatory PAEs across ambulatory care settings*				
		Total PAEs (%)	n (95% CI)	Physician's office	Home	Day surgery	Hospital clinic	ED
Children (2 days–20 years)	708	29.8	211 (225 to 196)	50.0	0.0	0.0	50.0	0.0
Non-elderly adults (21–64 years)	4366	13.4	583 (664 to 524)	31.8	13.6	9.1	0.0	45.5
Elderly adults (≥65 years)	4134	11.8	488 (550 to 426)	16.7	33.3	0.0	16.7	33.3

ED, emergency department; PAE, preventable adverse events.

*Row percentages.

higher levels of harm because it does not include AAEs that did not result in a hospital admission. However, these adverse events, because of their related harm, should probably be a priority for patient safety interventions. An additional limitation of the study, related to the small number of adverse events detected, suggests that undetected differences may exist in the number of events when stratified by type, site or medical specialty and need further clarification.

CONCLUSION

This study finds that ambulatory care can be a risky context of care that leads to hospital admission, injury and death. Annually, an estimated 75 000 US hospital discharges are related to preventable adverse events that occur in an ambulatory care setting, of which 10% result in serious permanent injury or death. Prevention of these events may be challenging because of the decentralised organisation of ambulatory care, the wide range of physicians (medical and surgical, primary care and specialists) providing care, and the diverse nature of the event types (eg, diagnostic, medication and outpatient surgery). Initial prevention efforts should focus on diagnostic and medication errors in general internal medicine and family medicine physicians' offices. Additional attention should be directed towards surgery in the ambulatory care setting because of the increasing volume and complexity of care. Specifically, further research is needed to better identify the risks related to ambulatory care surgeries and to guide regulatory organisations in the development of policies, practices and guidelines that promote safe surgery in ambulatory care settings. Lastly, this study shows that research about adverse events and preventable adverse events from hospital-based studies should be considered as an important source of information about risks that lead to harm in ambulatory care.

Authors' affiliations

Donna M Woods, Jane L Holl, Institute for Healthcare Studies, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA

Eric J Thomas, Department of Medicine, University of Texas Medical School at Houston, Houston, Texas, USA

Jane L Holl, Institute for Healthcare Studies, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA

Kevin B Weiss, Department of Medicine, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA

Troyen A Brennan, Aetna, Inc., Hartford, Connecticut, USA

Competing interests: None declared.

REFERENCES

- 1 **Cherry D**, Woodwell D, Division of Health Statistics. *National Ambulatory Medical Survey: 2000 Summary*. www.cdc.gov/data/has/tables/2003/03hus082.pdf.

- 2 **Hammons T**, Piland NF, Small SD, *et al*. Ambulatory patient safety: what we know and need to know. *J Ambulatory Care Management* 2003;**26**:63–82.
- 3 **Dovey SM**, Meyers DS, Phillips RL, *et al*. A preliminary taxonomy of medical errors in family practice. *Q Safe Health Care* 2002;**11**:233–8.
- 4 **Mohr JJ**, Lannon CM, Thoma KA, *et al*. Learning from errors in ambulatory pediatrics (LEAP). *Advances in patient safety: from research to implementation*. May, 2005.
- 5 **Woods DM**, Thomas EJ, Holl JL, *et al*. Adverse events and preventable adverse events in children's medical care. *Pediatrics* 2005;**115**:155–60.
- 6 **Fernald DH**, Pace WD, Harris DM, *et al*. Event reporting to a primary care patient safety reporting system: a report from the ASIPS collaborative. *Ann Fam Med* 2004;**2**:327–32.
- 7 **McGlynn EA**, Asch SM, Adams J, *et al*. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;**348**:2635–45.
- 8 **Thomas EJ**, Studdert D, Burstin HR, *et al*. Incidence and types of adverse events and negligent care in Utah and Colorado. *Med Care* 2000;**38**:261–71.
- 9 **Thomas EJ**, Studdert DM, Newhouse JP, *et al*. Costs of medical injuries in Utah and Colorado. *Inquiry* 1999;**36**:255–64.
- 10 **Agency for Healthcare Research and Quality**. HCUPnet. <http://hcupnet.ahrq.gov/HCUPnet.jsp>.
- 11 American Medical Association, Physician Characteristics and Distribution in the US, 2005. <http://www.bls.gov/oca/ocos074.htm#nature>.
- 12 American Board of Medical Specialties: General Certificates Issued, 1994–2004. <http://www.abms.org/Statistics.asp> (accessed 8 Feb 2007).
- 13 **Smith PC**, Araya-Guerra R, Bubblitz C, *et al*. Missing clinical information during primary care visits. *JAMA* 2005;**293**:565–71.
- 14 **Gandhi TK**, Sittig DF, Franklin M, *et al*. Communication breakdown in the outpatient referral process. *J Gen Intern Med* 2000;**15**:626–31.
- 15 **Hickner JM**, Fernald DH, Harris DM, *et al*. Issues and initiatives in the testing process in primary care physician offices. *Jt Comm J Qual Patient Saf* 2005;**31**:81–9.
- 16 **Nutting PA**, Main DS, Fischer PM, *et al*. Toward optimal laboratory use. Problems in laboratory testing in primary care. *JAMA* 1996;**275**:635–9.
- 17 **Murff HJ**, Gandhi TK, *et al*. Primary care physician attitudes concerning follow-up of abnormal test results and ambulatory decision support systems. *Int J Med Inform* 2003;**71**:137–49.
- 18 **Poon EG**, Gandhi TK, Murff HJ, *et al*. "I wish I had seen this test result earlier!" Dissatisfaction with test result management systems in primary care. *Arch Intern Med* 2004;**164**:2223–8.
- 19 **Poon EG**, Haas JS, Louise Puopolo A, *et al*. Communication factors in the follow-up of abnormal mammograms. *J Gen Intern Med* 2004;**19**:316–23.
- 20 **Hanna D**, Griswold P, Leape LL, *et al*. Communicating critical test results: safe practice recommendations. *Jt Comm J Qual Patient Saf* 2005;**31**:68–80.
- 21 **Gandhi TK**, Weingart SN, Leape LL, *et al*. Medication errors and potential adverse drug events among outpatients. *J Gen Intern Med* 2000;**15**(Suppl):116.
- 22 **Gandhi TK**, Weingart SN, Borus J, *et al*. Adverse drug events in ambulatory care. *N Engl J Med* 2003;**348**:1556–64.
- 23 **Lambert BL**, Lin SJ, Tan H. Designing safe drug names. *Drug Saf* 2005;**28**:495–512.
- 24 **Hajjar ER**, Hanlon JT, Artz MB, *et al*. Adverse drug reaction risk factors in older outpatients. *A J Geriatr Pharmacother* 2003;**1**:82–9.
- 25 **Pasternak LR**, Johns A. Ambulatory gynecological surgery: risk and assessment. *Best Pract Res Clin Obstet Gynaecol* 2005;**19**:663–79.
- 26 **Fleisher LA**, Pasternak LR, Herbert R, *et al*. Inpatient hospital admission and death after outpatient surgery in elderly patients: importance of patient and system characteristics and location of care. *Arch Surg* 2004;**139**:67–72.
- 27 Kohn LT, Corrigan JM, Donaldson M, eds. *To Err Is Human: Building a Safer Health System*. Institute of Medicine (IOM) Report. Washington, DC: National Academy of Sciences, 1999.
- 28 **Kiefe CI**, Allison JJ, Willaims OD, *et al*. Improving quality improvement using achievable benchmarks for physician feedback. *JAMA* 2001;**285**:2871–9.
- 29 **Verstappen WH**, van Merode F, Grimshaw J, *et al*. Comparing two cost effects of two quality strategies to improve test ordering in primary care: a randomized trial. *Int J Qual Health Care* 2004;**16**:391–8.