Mitigation of patient harm from testing errors in family medicine offices: a report from the American Academy of Family Physicians National Research Network

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ABSTRACT

Objectives: Little research has focused on preventing harm from errors that occur in primary care. We studied mitigation of patient harm by analysing error reports from family physicians' offices.

Methods: The data for this analysis come from reports of testing process errors identified by family physicians and their office staff in eight practices in the American Academy of Family Physicians National Research Network. We determined how often reported error events were mitigated, described factors related to mitigation and assessed the effect of mitigation on the outcome of error events.

Results: We identified mitigation in 123 (21%) of 597 testing process event reports. Of the identified mitigators, 79% were persons from inside the practice, and 7% were patients or patient's family. Older age was the only patient demographic attribute associated with increased likelihood of mitigation occurring (unadjusted OR 18–44 years compared with 65 years of age or older = 0.27; p = 0.007). Events that included testing implementation errors (11% of the events) had lower odds of mitigation (unadjusted OR = 0.40; p = 0.001), and events containing reporting errors (26% of the events) had higher odds of mitigation (unadjusted OR = 1.63; p = 0.021). As the number of errors reported in an event increased, the odds of that event being mitigated decreased (unadjusted OR = 0.58; p = 0.001). Multivariate logistic regression showed that an event had *higher* odds of being mitigated if it included an ordering error or if the patient was 65 years of age or older, and *lower* odds of being mitigated if the patient was between age 18 and 44, or if the event included an implementation error or involved more than one error. Mitigated events had lower odds of patient harm (unadjusted OR = 0.16; p<0.0001) and negative consequences (unadjusted OR = 0.28; p<0.0001). Mitigated events resulted in less severe and fewer detrimental outcomes compared with non-mitigated events.

Conclusion: Nearly a quarter of testing process errors reported by family physicians and their staff had evidence of mitigation, and mitigated errors resulted in less frequent and less serious harm to patients. Vigilance throughout the testing process is likely to detect and correct errors, thereby preventing or reducing harm.

Most patient safety studies in primary care settings have been descriptive, and those studies have led to a better understanding of the types of errors occurring in those setting, their consequences, and potential remedies.[1–13] However, little research in primary care has focused on activities that occur during an error event chain to prevent or minimise harm, which is called mitigation.[7 13 14]

The use of the term ''mitigation'' is not consistent in the patient safety literature; consequently, it is necessary for us to further specify our use of the term. We see mitigation taking place in what Van der Schaaf[15] describes as the ''dangerous situation''—the temporary state that follows the occurrence of a human error or system failure, before it resolves into its outcome. We distinguish it from ''recovery,'' which is the action of people or systems that takes place after the chain of events has played out. Nolan specifies three strategies for the design of safe healthcare systems: preventing errors, making errors visible, and mitigating the effects of errors.[16] His ''mitigation'' closely resembles our term ''recovery,'' whereas his ''making errors visible''—which he refers to as ''procedures or attributes that make errors visible to those working in the system so that they can be corrected before causing harm''—is part of our mitigation process. Our ''mitigation'' takes place when an error becomes visible (in our terminology, ''discovered'') and an intentional action is undertaken to avoid or reduce harm. Helmreich's three-tiered pyramid model of error management[17] distinguishes between avoiding errors, trapping those errors that are not avoided (our ''mitigation''), and mitigating those errors that are not trapped (our ''recovery''). If we draw an analogy to prevention, stopping an error from occurring is primary prevention, mitigation is secondary prevention, and recovery is tertiary prevention.

While some errors result in harm (preventable adverse events), others do not (close calls or near misses). Some errors do not cause harm by chance or because the errors are remote from patients, but others do not cause harm because humans or systems catch the errors and prevent or mitigate patient harm. A few researchers have investigated near misses, recovery from near misses, and mitigating behaviour in disciplines other than primary care.[15 18–22] An error frequently entails a chain of events that go wrong.[23] Interceding somewhere in the chain of events can prevent additional errors from occurring, stop them from reaching or harming patients, or reduce the amount of harm experienced. Such

mitigating behaviour in family medicine is the focus of this study.

As part of a larger event-reporting study of testing process errors in family physicians' offices,[24] we analysed the role of mitigation in these events. Specifically, the aims of this study were to assess (1) how often the reported error events were mitigated, (2) who the mitigators were, (3) what factors were related to the occurrence of mitigation, and (4) how the occurrence of mitigation affected the outcome of the error events.

METHODS

The database used for this analysis comes from a descriptive study of testing process errors reported by family physicians and their office staff.[24] The study took place in four private family medicine practices and four family medicine residency clinics in the American Academy of Family Physicians National Research Network (AAFP NRN). They were a mix of small and large practices in rural, urban and suburban locations.

We asked physicians, residents, nurse practitioners, physician assistants and office staff in the participating practices to anonymously report any errors related to the diagnostic testing process that they committed or became aware of during the course of their work day during a 32-week reporting period (April–November 2004). The reporting tool requested both free-text descriptions and multiple-choice responses. We did not ask questions that were directly related to mitigation. Before beginning the error reporting, a knowledgeable person in each office, generally the office manager, completed a survey describing the practice's policies and procedures, and other pertinent information about the practice's testing process. More details on the definition of errors, the reporting systems and schema in these practices, and the general taxonomy we used to code errors have been described elsewhere.[2 4 24]

Coding mitigation

For this study, we developed a taxonomy for coding mitigation of harm. We defined "mitigation" as an intended positive contribution of a person and/or a system during an error event that positively altered (mitigated or ameliorated) the course of the event. The action must have occurred during the course of the overall chain of events, not after the error event had run its course.

The mitigation taxonomy designed for this study is displayed in table 1. We based our taxonomy on the Applied Strategies for Improving Patient Safety (ASIPS) categorisation of people involved in mitigation[25] and the Eindhoven Classification Model, Medical Version[26] for the categorisation of systems and behaviours that were involved in mitigation.

Three of the authors, DG, EB and JH, coded the elements of the event reports related to mitigation. All three coded the first 50 reports. After discussion among them and DH, they agreed on final definitions and the coding scheme. The remaining reports were divided between the three coders, and at least two coded and compared every tenth report to ensure consistency. Periodically, we modified the mitigation coding scheme. When this occurred, we reviewed and, where necessary, recoded all of the previously coded reports to ensure consistency throughout all of the reports.

Predictors of mitigation

To assess predictors of mitigation, we analysed categories of characteristics related to the event report, practice, patient and error (table 2). Event report, patient and error characteristics were based on information provided in the event reports. Practice characteristics were based on responses to the practice survey. These predictors were derived from the experience of analysts involved in previous patient safety reporting work of the AAFP NRN and ASIPS.[1 2 4 9 24]

We grouped errors into one of six types based on the steps in the testing process—ordering, implementing, reporting the test result, responding to the test result, administrative issues, and a residual "other" category (see table 3 for a description of the kinds of errors that fall into each category). Since events could contain more than one kind of error, we created dichotomous variables—one for each of the six error types—to classify each reported event. Each of these six dichotomies was coded as "yes" if that type of error occurred in the reported event and as "no" if it did not occur.

Error-event outcomes

We included two types of event outcomes: (a) severity of harm to the patient as determined by the coder of the event report and (b) consequences (the result of the event to the patient, the patient's family, and/or the care provider (practitioner or practice)) as determined by the reporter of the event. We treated harm and consequences both as dichotomous and as ordered categorical variables. The values of these variables are presented in table 4. The ranking came from a combination of the AAFP analytic scheme, the ASIPS analytic scheme, the USP MedMARx Error Outcome Categories (severity scale)[27] and face validity. All event outcomes were gleaned by the coders from the narrative provided by the reporters.

Statistical analyses

We performed descriptive analyses using frequencies and percentages to describe events in which errors were mitigated or not, including the role and behaviour of the person identified as the mitigator. Next, we examined the statistical association between predictor variables and the presence or absence of mitigation. Finally, we treated mitigation as the predictor and examined the association between it and harm and consequences. Because the interclass correlation coefficient (ICC) among patients within practice sites for each outcome variable (mitigation, harm and consequences) indicated evidence of clustering (5.3%, 3.7% and 0.9%, respectively), we used multilevel analyses to determine statistical associations. All multilevel analyses were performed using the Glimmix macro in SAS version 9.1.

Exploratory unadjusted and adjusted analyses were performed to determine associations between mitigation and 24 characteristics of the event report, practice, patient and error (table 2). Simple multilevel logistic regression analyses were first performed for the outcome variable mitigation with each characteristic separately. The error characteristic variables, "perceived seriousness" and "number of errors," were treated as ordinal categorical variables in these and subsequent analyses.

A total of three multivariate logistic analyses were then performed, one for each outcome: mitigation, patient harm and consequences. Each model adjusted for error characteristics that were associated with mitigation at the bivariate alpha level of significance of 0.20. For the patient harm and consequences models, mitigation was run as an independent predictor in order to ascertain the effect of mitigation on each outcome, adjusting for other predictors

Table 1 Mitigation and recovery taxonomy

0. No mitigating factors can be identified
1. Person (purposive action or intervention by someone who is a participant in the event with the intent to alter [mitigate or ameliorate] the course of the event; usually requires doing something extra or out of the ordinary or going the extra mile)
  1.1 People involved
    1.1.1. Attending clinician (physician and NP & PA); clinician of record
    1.1.2. Non-attending clinician within the practice
    1.1.3. Consultant clinician outside the practice
    1.1.4. Other clinical staff within the practice
    1.1.5. Non-clinical staff within the practice
    1.1.6. Unidentified staff within the practice
    1.1.7. Patient/patient's family/patient representative
    1.1.8. Third party—clinical (eg, pharmacy/pharmacist/pharmacy tech; lab/lab tech; etc)
    1.1.9. Third party—non-clinical (eg, payer, regulator, supplier/vendor, etc)
    1.1.10. Unknown
  1.2 Behaviour
    1.2.1. Knowledge-based behaviours
    1.2.2. Rule-based behaviours
    1.2.3. Skill-based behaviours
    1.2.4. Discovered by chance
    1.2.5. Unknown behaviour
2. System (an existing system or protocol functions as intended to "catch" an error and mitigates or ameliorates it)
  2.1. Technical
    2.1.1. External
    2.1.2. Design
    2.1.3. Construction
    2.1.4. Materials
  2.2. Organisation
    2.2.1. External
    2.2.2. Transfer of knowledge
    2.2.3. Protocols/procedures
    2.2.4. Management priorities
    2.2.5. Culture
  2.3. Other

Table 2 Hypothesised (or expected) predictors of mitigation

Predictor characteristics	Characteristic subcategories
Event report	Reporter type (clinician/staff)
	Intensive reporting week (yes/no)*
Practice	Residency/non-residency
	Practice category (high-/low-quality testing processes)
	EMR (yes/no)
	No. of labs used (outside and inside)
	Percentage time report normal lab results to patients
	Percentage time report clinically insignificant abnormal lab results to patients
	Percentage time report abnormal lab results to patients
	Follow-up of abnormal results/results needing action are tracked (yes/no)
Patient	Age
	Race
	Familiarity of reporter with patient's health problems
	Complex health problem (yes/no)
	Chronic health problem (yes/no)
Error	Type error
	Seriousness of error
	Error related to specific patient (yes/no)
	No. of errors reported
	Cascade or independent errors (if more than one reported)
	Location of errors
	Seriousness of event
	Frequency of encountering events like this

*Intensive reporting occurred at staggered intervals during four of the 32 reporting weeks for each of the eight participating practices. Participants at each practice were instructed to report every diagnostic testing process error that they observed during their intensive reporting weeks.

Table 3 Examples of error types

Error types	Error-type examples
Ordering investigations	Needed test not ordered
	Wrong test ordered
	Unnecessary test ordered
Implementing investigations	Requested test not done
	Specimen improperly collected or stored
	Specimen lost
Reporting results to office	Test results not reported in a timely manner
	Correct test results not reported
	Results never received by office
Responding to results	Provided responded incorrectly to test results
	Provided failed to notice or respond to abnormal test results
	Provider inappropriately responded to incomplete test results
Administrative errors related to testing	Report filed before required action taken
	Report filed before review by doctor
	Report filed in wrong patient's chart
Other errors related to testing process	Referral process not followed
	Message lost
	Error in referral and discharge letter

Error reports included in analyses

We included in each outcome analysis only those events whose outcome status we could determine. Thus, sample sizes for each outcome analysis differ. The number of cases included in each analysis also varied due to missing information. Patient's race was the only characteristic missing in more than 5% of the reports. In addition, 52 error reports were not included in the multivariate analyses, since these events could not be related to a specific patient, and therefore patient demographics were not available. Sensitivity analyses that included these 52 cases confirmed that their elimination did not substantively affect our results.

This study was reviewed and approved by the University of Missouri-Kansas City Social Sciences Institutional Review Board, by the American Academy of Family Physicians Institutional Review Board and by individual site institutional review boards as required.

RESULTS

During the 32-week reporting period, 243 reporters submitted 597 event reports related to the testing process. We identified mitigation in 123 (21%) of the reported events.

We also identified a total of 126 individuals as initiators of actions intended to mitigate harm ("mitigator"). Three event reports involved two identified mitigators. Over three-quarters (79%) of the mitigators were persons from inside the practice (table 5). Seventy-six per cent of all practice mitigators whose role we could identify were clinicians. One-fifth of the mitigators were from outside the practice, including third-party personnel such as laboratory or pharmacy staff (13%) and the patient, family or patient representative (7%). No reporters identified a system or a practice protocol as the mitigator.

Table 4 Structure of harm and consequences variables

Harm		Consequences	
Dichotomous (present versus absent)	**Ordered categorical (by severity)**	**Dichotomous (present versus absent)**	**Ordered categorical (by seriousness)**
Present	Clinical harm	Present	Pain/suffering or clinical consequence
	Emotional harm		
Absent	No harm but some action required		Delay in care
	No harm, but did reach the patient		Time/financial consequence
	No harm, and did not reach the patient	Absent	No consequence

Predictors of mitigation

Table 6 presents logistic regression results for the 11 error characteristics associated with mitigation, at an alpha significance level of 0.20 or lower, unadjusted for other variables.

Event report attributes

A higher percentage of mitigated events were reported by practice staff compared with clinicians (practice staff: 24%, clinicians: 17%, unadjusted OR = 0.65 (0.43, 1.00); p = 0.089).

Practice attributes

None of the practice attributes in table 2 had statistically significant associations with mitigation, and only one (regular reporting of normal lab results) had a $p<0.20$. The odds of mitigation were not affected by whether the practice was a residency.

Patient attributes

Age was the only patient demographic associated with mitigation: patients 65 years of age or older had higher odds of mitigation compared with patients 18–44 years of age (unadjusted OR 18–44 years = 0.27 (0.14, 0.51); p = 0.007).

Error attributes—error type

Reported events with implementation errors (11% of the events) had lower odds of mitigation compared with those not containing them (unadjusted OR = 0.40 (0.23,0.69); p = 0.001), and reported events of reporting errors (26% of the events) had higher odds of being mitigated compared with reports not containing them (unadjusted OR = 1.63 (1.08, 2.46); p = 0.021). In addition, reported events with ordering errors approached higher odds of mitigation occurring, although this association was not statistically significant (unadjusted OR = 1.45 (0.90, 2.32); p = 0.124).

Other error attributes

As the number of errors reported in an event increased, the odds of that event being mitigated decreased (mean number of errors for mitigated vs non-mitigated events = 1.43 vs 1.71; unadjusted OR = 0.58 (0.42, 0.79); p = 0.001). Relative to events reported with only one error, those involving a cascade of errors had lower odds of mitigation (p = 0.033). Although not statistically significant, events perceived to be less serious by those reporting them approached a higher odds of mitigation compared with those perceived to be more serious (unadjusted OR = 0.83 (0.69, 1.00); p = 0.054) and errors not related to a specific patient approached a higher odds of mitigation compared with errors related to a specific patient (unadjusted OR = 0.58 (0.30, 1.09); p = 0.092).

Table 7 presents the results of the multivariate logistic regression analysis predicting the odds of an event being mitigated. Of the 11 variables in table 6 having a bivariate association with mitigation with a p value of 0.20 or less, we eliminated two from the multivariate analysis. "Error related to a specific patient" was not included because it became a constant once the 52 reports not associated with a patient were eliminated from this analysis. "Cascade of errors" was not included because of its high correlation with "number of errors." Patient's age, ordering error, implementation error and number of errors reported (used as an ordinal categoric variable) were all associated with mitigation in the multivariate analysis. An event had higher odds of being mitigated if it included an ordering error, and lower odds of being mitigated if the patient was between age 18 and 44, included an implementation error, or involved more than one error.

Outcomes of mitigation

Compared with unmitigated events, mitigated events had lower odds of either patient harm (unadjusted OR = 0.16 (0.07, 0.36); $p<0.0001$) or a negative consequence, (unadjusted OR = 0.28 (0.17, 0.45); $p<0.0001$) (table 8). In addition, mitigated events resulted in less severe or detrimental outcomes (table 9). Mitigated events were less likely to reach the patient and, when they did reach the patient, were less likely to result in harm, both emotional and physical. Similarly, when mitigated

Table 5 Mitigator roles and behaviours (may be more than one mitigator per event)

	Frequency	Percentage	Percentage identified in practice
Role			
Within the practice			
Attending clinician	32	25	62
Non-attending clinician	7	6	13
Other clinical staff within practice	6	5	12
Non-clinical staff within practice	7	6	13
Unidentified staff within practice due to insufficient information	47	37	–
Subtotal	99	79	100
Outside the practice			
Patient/family/representative	9	7	–
Third-party (eg, laboratory, pharmacy)	16	13	–
Protocol/procedure	0	0	–
Subtotal	25	20	–
Unknown	2	2	–
Total	126	100	–
Behaviours			
Knowledge-based behaviour	19	15	–
Rule-based behaviour	105	83	–
Skill-based behaviour	0	0	–
Unknown behaviour	2	2	–
Total	126	100	–

Table 6 Frequency of and odds ratios for mitigation by predictor variables of p value ⩽ 0.20

	Mitigated		Not mitigated			95% CI	
Predictors of mitigation	**n**	**%**	**n**	**%**	**OR**	**Lower**	**Upper**
Event reporter type (n = 596)							
Clinician	50	16.9	245	83.1	0.65	0.43	1.00
Staff	73	24.3	228	75.7	1.00	1.00	1.00
Total	123	20.6	473	79.4			
Practice lab reports normal results (n = 596)							
<75% of the time	51	17.1	247	82.9	1.00	1.00	1.00
>75% of the time	72	24.2	226	75.8	2.19	0.83	5.76
Total	123	20.6	473	79.4			
Patient age category (n = 524)**							
0–17 years	7	19.4	29	80.6	0.63	0.25	1.56
18–44 years	17	10.0	153	90.0	0.27	0.14	0.51
45–64 years	40	20.3	157	79.7	0.62	0.36	1.04
65+ years	36	29.8	85	70.2	1.00	1.00	1.00
Total	100	19.1	424	80.9			
Ordering error (n = 596)							
Yes	32	26.9	87	73.1	1.45	0.90	2.32
No	91	19.1	386	80.9	1.00	1.00	1.00
Total	123	20.6	473	79.4			
Implementation error (n = 596)**							
Yes	17	11.0	138	89.0	0.40	0.23	0.69
No	106	24.0	335	76.0	1.00	1.00	1.00
Total	123	20.6	473	79.4			
Reporting results error (n = 596)*							
Yes	56	25.6	163	74.4	1.63	1.08	2.46
No	67	17.8	310	82.2	1.00	1.00	1.00
Total	123	20.6	473	79.4			
Other investigation error (n = 596)							
Yes	15	15.6	81	84.4	0.60	0.33	1.08
No	108	21.6	392	78.4	1.00	1.00	1.00
Total	123	20.6	473	79.4			
Seriousness (mean, SE) (n = 590) (ordinal data: 1 = not very serious to 5 = extremely serious)	2.40	1.13	2.64	1.13	0.83	0.69	1.00
Error related to specific patient (n = 596)							
Yes	106	19.5	438	80.5	0.58	0.30	1.09
No	17	32.7	35	67.3	1.00	1.00	1.00
Total	123	20.6	473	79.4			
No. of errors (mean, SE) (n = 596)**	1.43	0.615	1.71	0.783	0.58	0.42	0.79
Cascade (n = 596)*							
Independent errors	4	12.9	27	87.1	0.40	0.14	1.19
Cascade of errors	39	16.7	195	83.3	0.58	0.38	0.90
Cascade of errors and independent errors	2	6.7	28	93.3	0.22	0.05	0.95
One error only	78	25.9	223	74.1	1.00	1.00	1.00
Total	123	20.6	473	79.4			

*p<0.05; **p<0.01.

events resulted in negative consequences, the consequences tended to be less severe than in non-mitigated events. The consequences were more likely to be time and financial consequences and less likely to be delay in care or physical or emotional pain and suffering

The associations between mitigation and both harm (adjusted OR = 0.23 (0.10, 0.54); p<0.001) and consequences (adjusted OR = 0.33 (0.19, 0.57); p<0.001) were not attenuated when the effects of other potential explanatory variables were taken into account (table 10).

DISCUSSION

Much of the descriptive research on medical errors in primary care has concentrated on reporting systems, errors and outcomes.[1–6 8 10 11] Little has been written about mitigation of harm. This is the first quantitative study in primary care to investigate how often mitigation occurs, who initiates the mitigation, predictors of mitigation and whether or not mitigation is associated with less negative consequences.

This study shows that a testing error event is more likely to be mitigated if the event includes an ordering error, and less likely to be mitigated if the event includes an implementation error or includes more than one error.

Most implementation errors occur in the transition to the laboratory or in the laboratory itself. It is likely that implementation error events either are lost in the transition between laboratory and office or, when they are recognised by individuals in the office, have cascaded past the point at which they could have been mitigated by family medicine clinicians and staff. In contrast, ordering errors occur early in an event and are more transparent to the family medicine office, so physicians and staff may do a better job of catching these errors before the event cascades out of control. Family medicine researchers have pointed out the important role of tracking

Table 7 Multivariate adjusted odds ratios for mitigation by selected correlates (n = 520)

Predictors of mitigation	OR	95% CI Lower	95% CI Upper	p Value
Reporter type				
Clinician	0.83	0.50	1.37	0.483
Staff	1.00	1.00	1.00	
Report normal results				
<75% of the time	1.00	1.00	1.00	0.534
>75% of the time	1.30	0.60	2.83	
Age category**				
0–17 years	0.48	0.16	1.41	0.009
18–44 years	0.27	0.14	0.53	
45–64 years	0.62	0.36	1.08	
65+ years	1.00	1.00	1.00	
Ordering error*				
Yes	1.88	1.03	3.42	0.039
No	1.00	1.00	1.00	
Implementation error*				
Yes	0.42	0.21	0.84	0.015
No	1.00	1.00	1.00	
Reporting error				
Yes	1.33	0.75	2.35	0.330
No	1.00	1.00	1.00	
Other error				
Yes	1.07	0.51	2.28	0.854
No	1.00	1.00	1.00	
Seriousness	0.92	0.74	1.15	0.476
No. of errors**	0.52	0.35	0.79	0.002

*p<0.05; **p<0.01.

systems for catching errors.[28] Once tests are ordered, staff need to be vigilant and make sure that tests are actually carried out and the results returned to the ordering clinician.

Events which include more errors, by definition, have cascaded further than events which include one error only. These multi-error events are more likely to get closer to the patient and consequently more likely to cause consequences to the patient and less likely to be mitigated early, before causing consequences.

Age is an interesting variable in this study. Error events that involved patients between 18 and 44 years were less likely to be mitigated. While the literature shows that older patients are less likely to be involved with medical decision-making and less likely to challenge the doctor's authority,[29–32] they (like children) visit the doctor more frequently than adults in the 18–44 age group.[33] Physicians and staff may be more familiar with these patients and more likely to discover, and consequently mitigate, errors that have occurred related to their healthcare. In addition, older people are often more "experienced" patients and thus more able to recognise when something goes wrong. Further, people aged 18–44 may be less concerned about their own healthcare and thus less likely to be careful about things that might go wrong.

Patients served as mitigators in only 7% of the reported events. This is in contrast to 15% of the events reported by Parnes *et al*.[13] However, Parnes *et al* did not limit their error reporting to the testing process only, and other types of errors may be more visible to or amenable to mitigation by patients. The low incidence in our study may also be due in part to its design, whereby only physicians and staff reported errors. Physicians and staff may not be aware of errors that are mitigated by patients or may not consider errors that are mitigated by patients as real errors. For example, staff may not report an error if they discover a lost test when a patient calls the office to retrieve test results because of not receiving notification of the results. Patients have the potential to be effective mitigators, as they have a different lens on events and can see things that are often missed by office staff. Offices should empower patients to contact them if things do not appear to be handled correctly.

Table 8 Frequency of and odds ratios for event outcome by mitigation

Predictor variable	Yes n (%)	No n (%)	OR	95% CI Lower	95% CI Upper	p Value
	Event outcome: patient harm (n = 430)					
Mitigation						
Yes	8 (7.0)	106 (93.0)	0.16	0.07	0.36	<0.0001
No	104 (32.9)	212 (67.1)	1.00	1.00	1.00	
Total	112 (26.0)	318 (74.0)				
	Event outcome: consequences (n = 503)					
Mitigation						
Yes	57 (48.3)	61 (51.7)	0.28	0.17	0.45	<0.0001
No	296 (76.9)	89 (23.2)	1.00	1.00	1.00	
Total	353 (70.2)	150 (29.8)				

This study also confirms the construct validity of our approach to mitigation in that mitigated events were less likely than unmitigated events to result in either patient harm or a negative consequence, even after controlling for other variables which may have been related to the outcome variables.

Although it was difficult to discern details of the mitigation process from the general narrative of the event reports received in this study, it appears that few reported errors were mitigated by systems that were in place in primary care offices. This demonstrates the continuing importance of people and cautions against over-reliance on current technological systems in primary care, as well as suggests the need for better systems.[34] It also may signify that clinicians and staff do not recognise errors that are mitigated by systems.

Limitations

There are several limitations to this study. Our findings regarding mitigation are limited by the anonymous nature of the event reports for this study and by the limited questions that were included in the report form. The results are based upon a secondary analysis of a dataset collected for other

Table 9 Frequency of severity of event outcome by mitigation

Event outcome	Mitigation Yes n (%)	Mitigation No n (%)	Total n (%)
Severity of patient harm*			
No harm—did not reach patient	68 (69.4)	88 (30.4)	156 (40.3)
No harm—did reach patient	13 (13.3)	67 (23.2)	80 (20.7)
No harm—action required	9 (9.2)	36 (12.5)	45 (11.6)
Harm—emotional	0 (0.0)	31 (10.7)	31 (8.0)
Harm—clinical	8 (8.2)	67 (23.2)	75 (19.4)
Total	98 (100.0)	289 (100.0)	387 (100.0)
Severity of consequences†			
No consequences	54 (53.5)	82 (23.0)	136 (29.8)
Time/financial	30 (29.7)	80 (22.5)	110 (24.1)
Delay in care	13 (12.9)	128 (36.0)	141 (30.9)
Pain/suffering/clinical	4 (4.0)	66 (18.5)	70 (15.3)
Total	101 (100.0)	356 (100.0)	457 (100.0)

*Likelihood ratio = 57.3, p<0.001; Spearman correlation = −0.333.
†Likelihood ratio = 53.7, p<0.001; Spearman correlation = −0.327.

Table 10 Multivariate logistic regression analysis of event outcome (patient harm and consequences)

	Patient harm (n = 374)			Patient consequences (n = 436)		
		95% CI			95% CI	
Predictor variable	OR	Lower	Upper	OR	Lower	Upper
Mitigation						
Yes	0.23***	0.1	0.54	0.33***	0.19	0.57
No	1	1	1	1	1	1
Reporter type						
Clinician	1.18	0.69	2	1.2	0.73	1.95
Staff	1	1	1	1	1	1
Report normal results						
<75%	1	1	1	1	1	1
>75%	1.05	0.63	1.77	0.99	0.57	1.72
Age category						
0–17 years	1.16	0.36	3.73	0.45*	0.16	1.25
18–44 years	0.87	0.42	1.81	0.56	0.3	1.04
45–64 years	1.35	0.68	2.68	1.41	0.76	2.61
65+ years	1	1	1	1	1	1
Ordering error						
Yes	0.63	0.32	1.24	0.94	0.51	1.75
No	1	1	1	1	1	1
Implementation error†						
Yes	2.90***	1.6	5.26	3.68***	1.82	7.46
No	1	1	1	1	1	1
Reporting error						
Yes	0.54	0.28	1.03	0.89	0.51	1.54
No	1	1	1	1	1	1
Other error						
Yes	1.26	0.61	2.58	0.79	0.38	1.65
No	1	1	1	1	1	1
Seriousness	1.27*	1	1.62	1.1	0.89	1.37
No. of errors	1.75**	1.2	2.53	1.66**	1.14	2.42

*p ⩽ 05; **p ⩽ .01; ***p ⩽ 001.
†Estimates for implementation error are unstable.

reasons. The form does not include specific questions about mitigators or mitigation. Consequently, we were able to glean this information only if it was provided by the reporter in response to the questions "What happened?", "What was the result?" and "What contributed to the event?" This limitation also prevented us from making extensive use of the taxonomy we developed for classifying mitigated events. We modified the "Participants" axis of the ASIPS taxonomy[1] to classify discoverers and mitigators, and also used parts of the Eindhoven Classification Model[26] for the Behaviour, Technical and Organization sections to further describe how individuals or systems mitigate errors and prevented them from cascading into harm. However, the limited narrative material in most error reports proved insufficient, and we were unable to follow-up with reporters due to the anonymous nature of the reports.

There were a few other limitations in this study. The reports are from physicians and office staff only. Lab staff and patients may have provided a different lens on mitigation. In addition, the difference between "mitigation" and "recovery" was not always clear in coding the event reports. As defined, "mitigation" refers to an action which occurs during the course of an event to alter the course of the event, while "recovery" occurs after the event is completed to correct a problem or address a harm. However, in primary care, the distinction is not always clear when an "event" is completed. For example, if a nurse noticed that she had not received the report from a lab within 1 week of when a lab test was implemented, and she consequently contacted the lab for the results—we considered that period of time as part of the "event" and coded the nurse as the "mitigator." However, if the nurse followed up 2 months following the lab test, she was coded as the "recoveror." It was not clear at what point during this 2-month period she changed from being a "mitigator" to being a "recoveror."

Finally, since data were collected for 32 weeks from April through Novermber, it is possible that there was a seasonal effect present for the mitigation of events that occurred between December and March, a very heavy-use period for medical care that was not accounted for.

In family medicine offices, mitigation is part of an error event chain and is intended to trap the effects of an error by early discovery and then taking steps to avoid or reduce harm. The study of mitigated events allows us to focus not on what can go wrong following an error, but on what can go right upstream to prevent having the situation cascade out of control and cause harm to patients. Further, identifying the types of events that are *less* likely to be mitigated will allow us to focus our energies on identifying why this is so and how to intervene in them to improve the safety of primary care. Of course, we should continue to strive to prevent errors from occurring in primary care (and in all healthcare), but we hope that research such as this study will further sensitise us to the value of discovering and mitigating those errors which nevertheless do occur before they can harm a patient, of empowering patients to contact offices if things do not appear to be handled correctly, of empowering clinicians and office staff to act when they discover an error, of developing protocols for mitigating discovered errors to inform and guide that action and of making errors more visible to all so that appropriate action can be taken.

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REFERENCES

1. **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.
2. **Dovey SM,** Meyers DS, Phillips RL Jr, *et al*. A preliminary taxonomy of medical errors in family practice. *Qual Saf Health Care* 2002;**11**:233–8.
3. **Elder NC,** Dovey SM. Classification of medical errors and preventable adverse events in primary care: A synthesis of the literature. *J Fam Pract* 2002;**51**:927–32.
4. **Phillips RL,** Dovey SM, Graham D, *et al*. Learning from different lenses: Report of medical errors in primary care by clinicians, staff, and patients. A project of the American Academy of Family Physicians National Research Network. *J Patient Saf* 2006;**2**:140–6.
5. **Elder NC,** Graham D, Brandt E, *et al*. The testing process in family medicine: Problems, solutions and barriers as seen by physicians and their staff. A study of the American Academy of Family Physicians National Research Network. *J Patient Saf* 2006;**2**:25–32.
6. **Woolf SH,** Kuzel AJ, Dovey SM, *et al*. A string of mistakes: The importance of cascade analysis in describing counting, and preventing medical errors. *Ann Fam Med* 2004;**2**:317–26.
7. **Kuzel AJ,** Woolf SH, Gilchrist VJ, *et al*. Patient reports of preventable problems and harms in primary health care. *Ann Fam Med* 2004;**2**:333–40.
8. **Gandhi TK,** Weingart SN, Borus J, *et al*. Adverse drug events in ambulatory care. *N Engl J Med* 2003;**348**:1556–64.
9. **Harris DM,** Westfall JM, Fernald DH, *et al*. Mixed methods analysis of medical error event reports: a report from the ASIPS Collaborative. In: Henriksen K, Battles JB, Marks E, and Lewin DI, eds. *Advances in patient safety: from research to implementation*. *Vol. 2. Concepts and methodology*. Rockville, MD: Agency for Healthcare Research and Quality, 2005:133–47.
10. **Poon EG,** Gandhi TK, Sequist TD, *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.

11. **Graber ML,** Franklin N, Gordon R. Diagnostic error in internal medicine. *Arch Intern Med* 2005;**165**:1493–9.
12. **Gandhi TK,** Kachalia A, Thomas EJ, *et al*. Missed and delayed diagnoses in the ambulatory setting: A study of closed malpractice claims. *Ann Intern Med* 2006;**145**:488–96.
13. **Parnes B,** Fernald D, Quintela J, *et al*. Stopping the error cascade: a report on ameliorators from the ASIPS collaborative. *Qual Saf Health Care* 2007;**16**:12–16.
14. **Gandhi TK.** Fumbled handoffs: One dropped ball after another. *Ann Intern Med* 2005:**142**;352–8.
15. **Van der Schaaf TW.** Near miss reporting in the chemical process industry. Eindhoven, Netherlands: Technische Universiteit Eindhoven, 1992.
16. **Nolan TW.** System changes to improve patient safety. *BMJ* 2000;**320**:771–3.
17. **Helmreich RL,** Merritt AC, Wilhelm JA. The evolution of crew resource management training in commercial aviation. *Int J Aviat Psychol* 1999;**9**:19–32.
18. **Kaplan HS,** Fastman RB. Organization of event reporting data for sense making and system improvement. *Qual Saf Health Care* 2003;**12**(Suppl II):ii68–72S.
19. **Battles JB,** Dixon NM, Borotkanics RJ, *et al*. Sensemaking of patient safety risks and hazards. *Health Serv Res* 2006;**41**:1555–75.
20. **Kanse L,** van der Schaaf TW, Vrijland ND, *et al*. Error recovery in a hospital pharmacy. *Ergonomics* 2006;**49**:503–16.
21. **Henneman EA,** Blank FS, Gawlinski A, *et al*. Strategies used by nurses to recover medical errors in an academic emergency department setting. *Appl Nurs Res* 2006;**19**:70–7.
22. **Callum JL,** Kaplan HS, Merkley LL, *et al*. Reporting of near-miss events for transfusion medicine: improving transfusion safety. *Transfusion* 2001;**41**:1204–11.
23. **Reason J.** *Human error*. Cambridge: Cambridge University Press, 1990.
24. **Hickner JM,** Graham DG, Elder NC, *et al*. Testing process errors and their harms and consequences reported from family medicine practices: a study of the American Academy of Family Physicians National Research Network. *Qual Saf Health Care.* 2008;**17**:194–200.
25. **The ASIPS Collaborative**. Dimensions of medical outcome. The ASIPS-Victoroff taxonomy 2003. http://www.errorsinmedicine.net/taxonomy/ (accessed December 2006).
26. **Battles JB,** Kaplan HS, Van der Schaaf TW, *et al*. The attributes of medical event-reporting systems: Experience with a prototype medical event-reporting system for transfusion medicine. *Arch Pathol Lab Med* 1998;**122**:231–8.
27. **US Pharmacopeia**. *Summary of information submitted to MedMARx in the year 2002: the quest for quality*. Rockville, MD: The United States Pharmacopeial Convention, 2003.
28. **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.
29. **Belcher VN,** Fried TR, Agostini JV, *et al*. Views of older adults on patient participation in medication-related decision making. *J Gen Intern Med* 2006;**21**:298–303.
30. **Benbassat J,** Pilpel D, Tidhar M. Patients' preferences for participation in clinical decision making: a review of published surveys. *Behav Med* 1998;**24**:81–8.
31. **Levinson W,** Kao A, Kuby A, *et al*. Not all patients want to participate in decision making. A national study of public preferences. *J Gen Intern Med* 2005;**20**:531–5.
32. **Say R,** Murtagh M, Thomson R. Patients' preference for involvement in medical decision making: a narrative review. *Patient Educ Couns* 2006;**60**:102–14.
33. **Hing E,** Cherry DK, Woodwell DA. *National Ambulatory Medical Care Survey: 2004 Summary. Advance data from the vital and health statistics; no. 374*. Hyattsville, MD: National Center for Health Statistics, 2006.
34. **Cook RI,** Render M, Woods DD. Gaps in the continuity of care and progress on patient safety. *BMJ* 2000;**320**:791–4.