Original Article

Evaluation of a Web-based Error Reporting Surveillance System in a Large Iranian Hospital

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Abstract

Background: Proper reporting of medical errors helps healthcare providers learn from adverse incidents and improve patient safety. A well-designed and functioning confidential reporting system is an essential component to this process. There are many error reporting methods; however, web-based systems are often preferred because they can provide comprehensive and more easily analyzed information. This study addresses the use of a web-based error reporting system.

Methods: This interventional study involved the application of an in-house designed "voluntary web-based medical error reporting system." The system has been used since July 2014 in Nemazee Hospital, Shiraz University of Medical Sciences. The rate and severity of errors reported during the year prior and a year after system launch were compared.

Results: The slope of the error report trend line was steep during the first 12 months (B = 105.727, *P* = 0.00). However, it slowed following launch of the web-based reporting system and was no longer statistically significant (B = 15.27, *P* = 0.81) by the end of the second year. Most recorded errors were no-harm laboratory types and were due to inattention. Usually, they were reported by nurses and other permanent employees. Most reported errors occurred during morning shifts.

Discussion: Using a standardized web-based error reporting system can be beneficial. This study reports on the performance of an in-house designed reporting system, which appeared to properly detect and analyze medical errors. The system also generated follow-up reports in a timely and accurate manner. Detection of near-miss errors could play a significant role in identifying areas of system defects.

Keywords: Iranian hospitals, medical errors, near-miss errors, web-based reporting systems

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Introduction

Medical errors can pose serious threats to patient safety and health. Estimates made in the United States indicate medical errors to be among the top causes of premature death. When proper preventive methods are applied, the rate of medical errors can be reduced.[1,2]

The application of event analysis to improve medical care began in the 1940s. Proper reporting and investigation of medical errors could improve patient safety and health.[3] In 2005, the World Health Organization developed guidelines for implementing medical error reporting systems, which are essential components of effective patient safety programs.[4]

In 2001, the Institute of Medicine's (an arm of the United States National Academy of Sciences) Committee on Quality of Healthcare indicated that health professionals and organizations, policy makers and patients are aware of the shortcomings of the nation's current system and of the importance of finding new and better approaches to meet health care demands. Faced with rapid changes in needs and resources, the US health care delivery system needs to improve its ability to translate knowledge into practice and to apply new technology uniformly. For example, Americans today live longer than ever and now suffer more chronic than acute diseases. Yet, medical care today can be very complex, lacking coordination. Medical systems must be constantly evaluated and reinvented. The Committee generated a list of six aims for improvement. One of these aims was safety –avoidance of injuries to patients from the care that is intended to help them. Addressing medical errors will improve the overall quality of patient care.[5,6]

Coverage, quality and dependence on health information technology (HIT) have increased markedly over the last 30 years. Electronic health records, data entry port in clinical areas, even bedside, direct prescriber order entries, bar coding and specialized web-based reporting systems are commonplace now. So, how can HIT best help identify, describe and help reduce medical errors?[7,8]

When compared to conventional error reporting methods, web-based systems appear to be more user-friendly and less expensive plus capable of providing confidential, more readily analyzed information. Web-based systems can record complete details of adverse events, providing opportunities for early assessment and intervention.[9,10] Several studies have demonstrated the effectiveness of web-based reporting systems in helping reduce the number of adverse events and data gathering costs.[11,12] However, other reports suggest a lack of efficacy and no improvement in patient safety.[7,13,14]

Nemazee Hospital is a teaching hospital with 750 inpatient beds.

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It provides general, specialist and subspecialist care to more than 40,000 patients annually in the southern city of Shiraz, Iran. In the past, the hospital used a traditional medical error reporting system (paper and pencil). Hospital safety experts were unable to completely assess medical errors and thus, identify error origins or provide appropriate possible solutions in a timely manner. The need for a high quality, comprehensive system with better data analyzing capabilities led hospital personnel to develop an in-house web-based reporting system, which appears to be the first used in Iran. In this study, we evaluated the impact the newly developed system had on identification and reporting of medical errors, ease of data analyses and the quality of generated reports. Better error reporting should lead to improved patient care.

Materials and Methods

In this before-and-after interventional study, an in-house designed voluntary web-based medical error reporting system began to be used in July 2014. Previously, adverse event reports were collected using a paper-based system. The number and differing characteristics of reported errors that occurred a year before and a year after implementation were compared.

Web-based Reporting Software

First, paper error reporting forms were designed in accordance with standard international definitions using relevant national/international resources. Several drafts were circulated among small groups of hospital personnel and revised following consultations with health care personnel including nurses, medical students and physicians. Then, the newly developed forms were piloted in a few wards, followed by additional necessary modifications. A software package was then developed based on the final version of the piloted error reporting form.

In order to discuss the importance of reporting errors, types of possible errors, comparison of web-based systems to traditional paper/phone formats and successful completion of online forms, the research team organized group and face-to-face training courses starting in July 2013. Also, some participants were selected to serve as educational facilitators responsible for training and informing other personnel. Finally, the software was installed on the hospital website where it could be accessed anytime and anonymously.

The reporting software icon was linked directly to an electronic form that led users through two series of questions. The forms required a limited amount of typing. The goal was to collect large amounts of accurate data in the shortest period of time. The first part of the form required certain responses, such as date, time, location, services being provided, description of the event, patient age and gender, personnel occupation, work shift, severity of event (e.g., fatal, disabling or non-fatal), category of event (surgical and procedural, products or devices, patient care, security and criminal, medication, physical environment, diagnosis and treatment, radiology, and laboratory), type of event (no harm, near miss, and harmful), adverse outcomes by error and other factors. In the second part of the form, there were optional items designed to generate trust and a sense of security among health care personnel, which included position description and employment status of reporters and relevant suggestions. The reporting process took an average of ten minutes.

Prior to online use of the reporting system, data from the previous hospital error reporting system obtained between July 2013 and June 2014 were collated and analyzed. We determined the total number of reported errors and types of events defined as being before intervention (sentinel, no harm or near miss). Once the system was in operation, all electronic and non-electronic reports made between June 2014 and May 2015 were collected and compared in terms of frequency and placed into one of three groups of errors defined before intervention (sentinel, no harm or near miss). Electronic error reports were also observed separately and reports of the frequency of errors (overall and individually based on variables) were prepared.

Definitions

Severity of events was defined as sentinel events (an unpredicted incident involving death or serious physical /psychological damage, or risk of a serious outcome) and non-sentinel (all other events not classified in the first group).

Event types included near misses (non-occurrence of a potentially harmful event owing to good fortune or activation of a back-up care system), no harm events (occurrence of an event that did not result in patient harm, but risk of potential harm remains till the end of process) and harmful event (occurrence of an event that harmed a patient).[12]

Statistics

Descriptive statistics were used to report frequency of data in study figures and tables. Variances between numbers of reported errors that occurred during different shifts underwent Chi-square analyses. Also, regression tests were used to evaluate secular trends and perform correlation tests to identify relationships between the number of inpatient-days and reported errors during different months. $P < 0.05$ was considered as significant.

Results

This investigation was designed to evaluate the impact of an in-house designed web-based error reporting system on the rate and other related aspects of medical errors in Nemazee Hospital, Shiraz, Iran. Over the 24 months of study, the number of reported errors increased (B = 40.85, $P = 0.00$) (Figure 1) with a steeper trend line slope developing during the first 12 months (B = 105.727, $P = 0.00$) as compared to the next 12 months after system launch, which was no longer statistically significant (B = 15.27, $P = 0.81$).

During the year before the launch of the online system (July 2013 through June 2014), 18,936 errors involving 232,247 patient-admission days were reported. This included 13 sentinel, 6083 no harm, 12,811 near misses and 29 unidentified events. No significant correlation was observed between inpatient-days and the number of reported errors in different months ($P = 0.42$, r = 0.26). Non-electronic reports included only different types (sentinel, no harm, and near miss errors) of errors.

Web-based Reports

From July 2014 through June 2015, 23,883 errors (1359 electronic and 22,524 non-electronic) were reported and involved 235,305 inpatient-days. Non-electronic reports did not describe the categories of events, error types or severity or causes of errors. No significant correlation was noted between inpatient-days and number of reported errors ($P = 0.72$, r = 0.11) during different

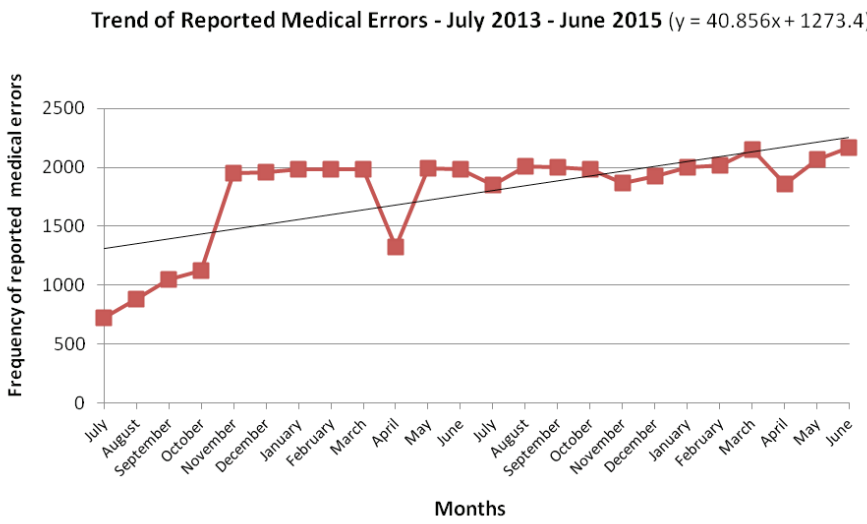

Figure 1. Trend of Reported Medical Errors - July 2013 – June 2015.

months. The total number of online reported errors was 1359 for 235,305 inpatient-days during this period, of which 610 cases (45%) were sentinel errors with no significant correlation between inpatient-days and reported errors rate in different months (P = 0.2, r = 0.39). Thirty-two events were reported by the individual who committed the error, while 1327 cases were recorded by an observer.

The majority of reported errors in most study months were of no harm type (n = 921, 67.8%) (Figure 2), followed by near-misses (n = 269, 19.8%). There were some harmful events (n = 169, 12.4%). Also, 112 (8%) cases of reported errors led to patient death or disability. In terms of category type, most were laboratory errors while the fewest were safety and criminal errors. The majority of reported errors from all areas were of "no harm" type (Figure 3). The majority of reported laboratory errors occurred before analysis. Near-miss errors were the most common type in both the laboratory and medication categories. However, harmful errors were the most common type in the patient care category (Figure 4).

Negligent inattention (n = 835) was the most common cause of errors among studied adverse events. This was followed by nursing care failures (n = 376), lack of knowledge (n = 243), insufficient physician care (n = 207), fatigue (n = 135), manpower deficiency (n = 132), crowded departments (n = 84), non-observance of principles of infection control (n = 75), incorrect or delayed diagnosis (n = 23) and unavailability of shift physician (n = 5).

Figure 5 presents the reasons for errors among various categories with inattention being the most common cause. Medication errors, patient care and laboratory incidents, nursing care failures were the second most common causes. Errors in the surgery category often involved failure in physician care. Finally, poor physician care played a principal role in the occurrence of diagnosis and treatment errors, followed by inattention and inadequate knowledge.

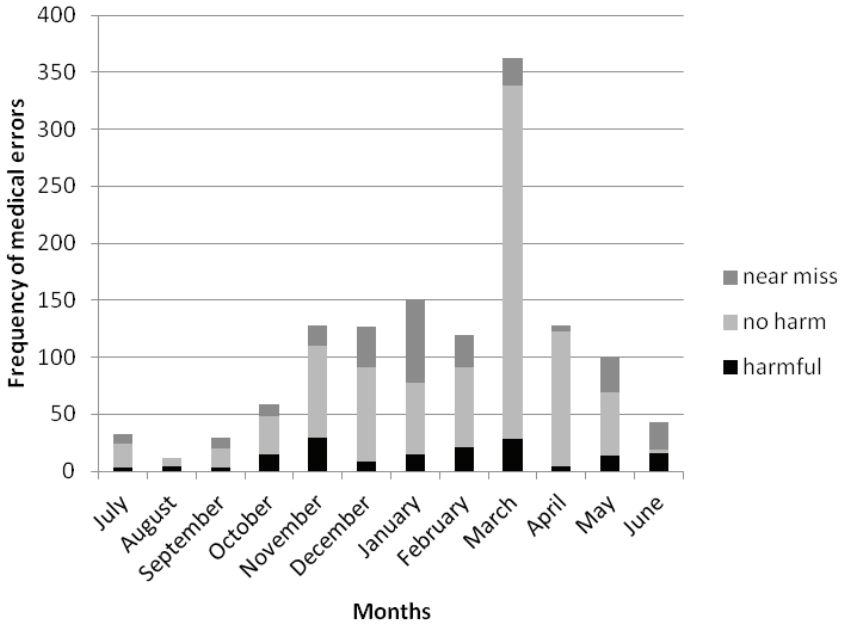

Figure 2. Monthly Frequency of Web-based Reported Medical Errors by type- July 2014 – June 2015.

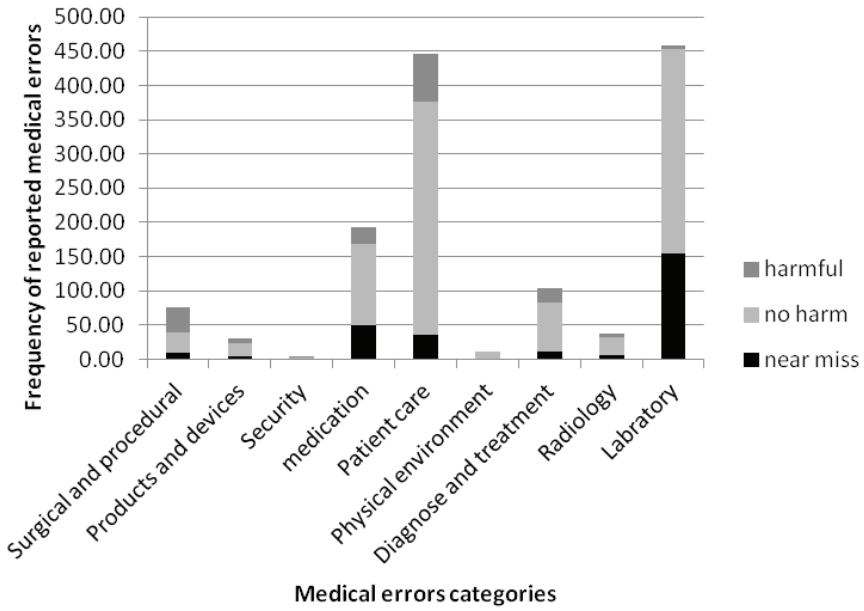

Figure 3. Frequency of Reported Medical Errors by Type and Category (July 2014 – June 2015)

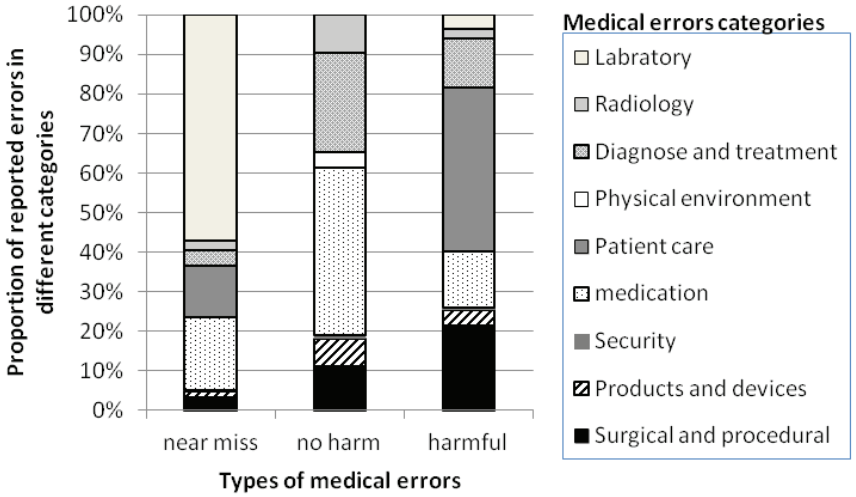

Figure 4. Proportion of different categories within types of errors (July 2014 – June 2015).

The majority of reported errors occurred during morning shifts (n = 686), while the lowest rates involved night shifts (n = 300). A total of 373 mishaps occurred during afternoon shifts. Variance between reported errors rates and working shifts was significant (χ^2 = 185.6, P = 0.00). Morning and afternoon shifts are six hours long, while the night shift lasts 12 hours; however, shift differences still remained significant even after taking the number of working hours into consideration (χ^2 = 43.5, P = 0.00). No significant variances in reported errors were noted when the mean number of personnel per shift was analyzed (P = 0.78).

Table 1 reports the frequency of self-reporting errors by hospital position. Nurses committed the greatest number of errors (n = 766, 56.36%). Nurses comprised the greatest number of hospital workers (1420) involved in this study. The number of errors reported divided by the number of individuals yielded a ratio value. The value for nurses was 0.54. The highest ratio came from paraclinical staff, while the lowest ratio occurred among students.

Table 2 lists the number of errors reported by position group. Nurses were involved with 51.37% of all reported errors. Laboratory workers were second at 42.65%. All other groups had involvement values below 4.0%. Results indicate that the vast majority of errors involved permanent employees.

Discussion

The aim of this study was to measure the potential effects of a voluntary web-based reporting system on the number and various characteristics of reported medical errors in a large hospital. As a practical, timely, confidential and precise method, the web-based error reporting systems could offer a new method of investigating medical errors and developing an improved learning culture. Several studies showed the potential capabilities

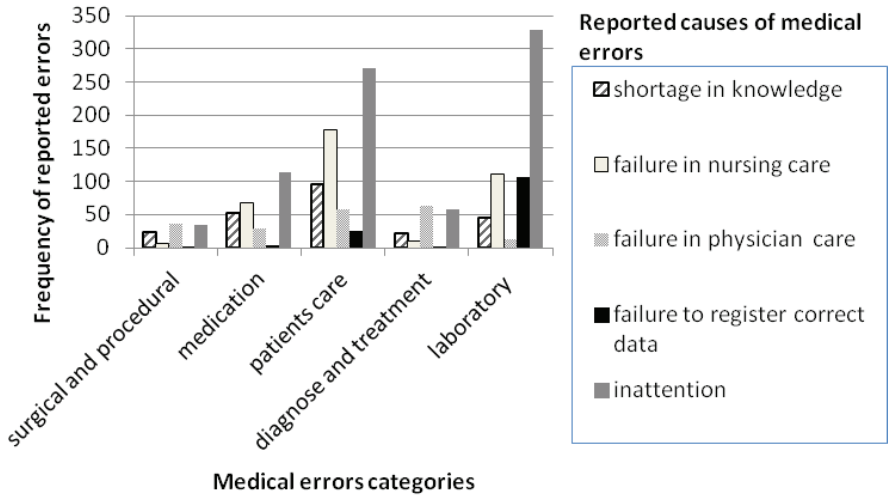

Figure 5. Causes of errors reported by staff within more frequently reported categories (July 2014 – June 2015).

Table 1. The frequencies of errors within position of person who did/made the error.

Position of person who made the error	Number of errors (percentage of total reports)	Number of Staff	The ratio of the number of error in any position to the number of personnel in same position
Nurse	766(% 56،36)	1420	0.54
Administrative personnel	92 (6.77٪)	541	0.17
Personnel of Pharmacy and medical equipment	23 (1.69٪)	37	0.62
Student	21 (1.55٪)	247	0.09
physician	191(14.05٪)	660	0.29
Paraclinical staff	198 (14.57٪)	200	0.99
Other	68 (5٪)	327	0.21

Table 2. The frequency of errors reporting within different positions of personnel.

Positions of error reporter	The number of reports (relative to the total personnel within the positions)	Percentage of total reports (%)
Nurse	371 (0.26)	51.37
Speciality and subspecialty physician	1 (0.002)	0.13
Laboratory staff	308 (2،8)	42.65
Radiology staff	14 (0.15)	1.93
Administrative personnel	25 (0.05)	3.45
Other	3(0.01)	0.41
Total	722	100

of the online reporting method for improving the quantity and quality of reports.[9] However, there are other studies that reported contradicting or equivocal results.[13,14]

Following the introduction of the web-based system, the total number of reported errors increased compared with the previous year. The upward slope of reported errors over the 24 months of study was steeper during the first 12 months. In fact, during the first five months (start of staff training), there was a dramatic rising trend in the number of reports, which slowed over the second 12 months, with approximately the same number of inpatient-days (235,305 vs. 232,247), without any rise in the number of hospital personnel. After launching the online system, the leaning slope remained positive, but not statistically significant (B = 15.27, *P* = 0.81). Some US studies indicated significant increases in the number of reported errors after initiation of an online system,[6,7,15] but other investigations did not have similar results.[10,13,14]

Introduction of the web-based system and associated employee instruction were the most significant alterations made during the study period. The aim was to increase personnel awareness of medical errors and the reporting methods. The desired outcome was an increase in the frequency of reports.

Using the previous non-electronic method for reporting medical errors, one error was reported for every three patient admissions (18,936 reports for 54,589 hospital admissions). After launching the online reporting system in the following year, one error (electronic and non-electronic combined) was reported for every two admissions (23,883 reports for 49,981 admissions). These results appear to match those of a US study which reported that

one-third of hospital admissions resulted in one medical error.[6] In this study, confidential reporting appeared to help increase the number of errors reported.

Conversely, during the year prior to implementation, one error was reported for every 12 inpatient-days (non-electronic), while in the year after implementation, there was one error reported for every ten patient-days (more than 95% non-electronic), which is much higher than a US study of online reporting, which found one reported medical error for every 52 inpatient-days.[9]

The proportion of online reports (2.7 for every 100 admissions or six reports per 1000 inpatient-days) was much lower in the overall number of reports (electronic and non-electronic) from other international studies. A 2006 US study of several hospitals showed that 3% of patients suffered an undesirable side-effects associated with hospitalization. Reported errors ranged from 9–95 per 1000 inpatient-days in hospitals that had used a web-based system for less than two years. A 2014 Australian emergency room study which used online reporting indicated a much lower (0.08%) error rate.[9,17]

In the present study, nearly two thirds of online reports were in the no-harm class. Most near-miss and harmful errors came from hospital laboratories. These are similar to the results of Milch *et al*.[9] In two other comparable surveys from the Netherlands and Portugal, the rates of no-harm events were 32.4 % and 61%, respectively.[18,19] Reporting of no-harm errors helped to identify system defects and possible error origins.[1,20]

The rate of harmful events was three cases for every 1000 admissions (n=154, 0.6%), which was smaller than that of Milch *et al*. in 2006 (almost 1% of errors) and McKaig *et al.* in 2014.[9,15] However, considering the number of admissions in this study, the rate of harmful errors was higher than those found in other studies.[21]

In this study, there was no significant correlation between the number of patients in consecutive months and the total number of reports before and after the application of the web-based reporting system. This was true for both electronic and non-electronic reports. Also, there was no reported association between the number of hospital beds and error reporting rate, especially in hospitals with less than 24 months of online system use.[9] The short period of our online system use (one year) could help explain our results.

In this investigation, the greatest number of errors involved laboratories, followed closely by patient care and medication errors. In two other Iranian studies, treatment errors (comparable to medication and surgical / procedural errors here) had the highest rate, followed by errors in recording physician orders and para-clinical mishaps.[22,23] Inconsistencies might be due to differing definitions, level of significance assigned to each error by personnel and the launching of a laboratory quality control system over the past year in Nemazee Hospital. These cases emphasize the need for use of a government-supported standard reporting system in terms of content, form and process.[10]

Like other investigations, the present study revealed that concerning surgical and procedural events, a proportion of surgical errors were severe, probably due to inattention, failures in physician care and lack of knowledge. On the other hand, medication errors had the highest incidence of moderate to severe events and laboratory errors were the most noticeable in near misses. This mismatch was probably due to the large number of laboratory error reports compared to other studies.[9]

Despite significant differences between working shifts in terms of reporting errors, these difference disappeared when the number of personnel in each shift was taken into account. This might be because of the influence of increased personnel on incidence rates or reporting of errors first thing in the morning. Other surveys reported varying conflicting results. Some of them indicated that the highest incidence of errors occurred during the morning shift, while others had the highest rates at night or during holiday periods[22,24,25] or during the afternoon shift.[26] However, none of these studies took into account the number of personnel present during a given shift. It appears that shift length did not correlate with the number and origins of errors. Gold *et al.* found that different working shifts had the greatest association with the rate of medical errors. Usually the number of patients remains somewhat constant; however, worker numbers can vary significantly. Admi *et al.*, did not find any difference in error reporting rates based solely on work shift.[27,28]

Web-based reports indicate that most physicians preferred to share their errors on paper. Conversely, nurses, in general, are less willing to share their errors. Nurses were less likely to share their errors on paper than when using electronic reporting methods (56% vs. 60–72%), while the opposite was true for physicians (14% vs. 2.6–9%).[29]

In this study, the greatest number of reports were made by nurses (nearly 51%) and the smallest came from physicians (less than 1%). In similar studies done in the US, less than 2% of errors came from physicians.[15,30] This might be due to differences in understanding of unwanted events vs. medical errors, training, numbers of nurses versus numbers of physicians and encouragement of nurses to report medical errors. On the other hand, physicians in Nemazee Hospital in the past have not received training concerning systematic assessment of errors and unwanted events. Therefore, most physicians believe that reporting errors involves assessing blame and punishing those involved. Moreover, physicians often avoid reporting errors because of professional courtesy toward colleagues or fear of reprisal.[5,31] Errors were mostly reported by permanent personnel (via formal/contractual employment) that could be a result of longer work experience, better awareness regarding importance of reporting errors, as well as being less concerned about consequences of reporting for their employment status than others. Errors were usually identified and reported by an observer rather than the responsible individual, probably because of obliviousness of the liable person or anxiety about reporting repercussions.

Limitations

An important limitation of this study was the reliance on reported errors (self-reporting or by observer), which is highly dependent on human behaviors, plus contextual environments and cultural conditions.[13] Of course, there was also a definite risk for under-reporting and reporting bias.[16] Nevertheless, this kind of reporting can provide important sources of information for the Clinical Quality and Governance Committees.

Also, there is the possibility of reporting one error several times or grouping several errors into one. Linking paper to electronic reporting may not always yield ideal direct comparisons. Such difficulties were also reported in a similar study conducted in the US.[9]

In conclusion, using a standardized web-based error reporting system has advantages that include the possibility of anytime/

anyplace reporting in an anonymous manner. Rapid reporting of errors could increase the chances of accurate reporting, and makes analysis, report generation and follow-up easier and more efficient. Unlike other retrospective reviews of records, web-based reporting systems are capable of identifying near misses and system defects. Synchronized and comprehensive use of standardized web-based error reporting systems in all Iranian hospitals could provide the possibility of effective report comparisons, thus increasing the chances for more uniform policy-making in all healthcare centers.

Implications of all the available evidence

Shiraz University of Medical Sciences will always need accurate information concerning medical errors. This study supports the value of the in-house developed standardized web-based error reporting system used to measure medical errors. Additional validation studies need to be conducted in the 800 Iranian hospitals to help develop a web-based national medical error reporting system.

Conflict of Interest statement: Nothing to declare.

Ethical issues

Approval for this study was given by the Ethics Committee of Shiraz University of Medical Sciences with Ethical Code EC-p-9374-7134.

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