

ORIGINAL ARTICLE

Evaluation of the Electronic Adverse Drug Event Management System

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Background: An electronic reporting system is indispensable in facilitating adverse drug event (ADE) management. Much of the literature has shown that not only the ADE report rate can be increased significantly by a well-designed electronic system but also the communication between health care professionals can be improved. Moreover, developing an electronic reporting system is essential for preventing ADEs in a cost-effective manner.

Purpose: The purpose of this study was to compare the efficiency and influence of an electronic ADE management system with a traditional working model at a medical center.

Methods: An electronic ADE management system was integrated with the four intranet systems in the hospital and made available at every computer terminal. An ADE committee met once every 4 weeks to discuss the strategies to promote the rational use of drugs, such as introducing an automated computer warning system based on sentinel cases. Details of ADEs were collected for 39 months before and after the new system was introduced. Characteristics of ADEs before and after implementation of the new system were analyzed using the χ^2 test.

Results: The number of ADE reports increased 3.6-fold after the electronic system (394 cases in contrast to 108 cases, $p < 0.001$) was established. ADEs reported by physicians increased from 36 (33%) to 222 (56%), and those reported by nurses increased from 0 (0%) to 72 (18%). Additionally, the percentage of preventable ADEs decreased significantly from 53% to 21% ($p < 0.001$). The distribution of ADE severity patterns and varieties of medication involved were also significantly affected by the system ($p < 0.001$).

Conclusion: The electronic ADE management system evidently increased interdisciplinary involvement that led to enhanced medication safety. Moreover, continuous operation and improvement of the management system by incorporating technologies to fit future demands of ADE management is essential for improving patient safety.

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1. Introduction

To encourage the reporting of adverse drug events (ADEs), an electronic reporting system is indispensable in facilitating ADE management.¹ Many institutes have been struggling with under-reporting and poor interdisciplinary involvement in ADEs.² However, studies have shown that the number of ADE reports can be increased by at least 50% over a 6-month period by introduction of the electronic reporting system.² It should be noted that all health care professionals provide pivotal information on managing ADEs,³ and enabling nurses to report electronically has been proven to increase ADE reports from 4.41 to 6.5 per month.¹

Establishing an efficient electronic system can further advance the interdisciplinary participation. A well-designed electronic system easily accessible by all appropriate health care professionals is crucial in enabling efficient interdisciplinary communication and managing ADEs.

It is well documented that more than a quarter of ADEs are preventable, and use of effective strategies can successfully manage these common events.⁴ The national cost of preventable in-hospital events because of ADEs has been estimated at about \$2 billion per annum in the United States,⁵ and pharmacist intervention has been indicated as an effective strategy to reduce this cost.^{6,7} In the study by Murray et al,⁸ the risk of an ADE was 35% lower in the pharmacist-intervened group, indicating the possibility of saving \$631,000 annually in a 50,000-patient outpatient setting. Use of information technology is also cost-effective in preventing ADEs related to medication errors by saving up to 1226 days of hospitalization and \$1.4 million of direct hospital costs.⁹ Hope et al¹⁰ demonstrated that a professional tiered review approach based

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on a computer-detected signal system was able to save \$26.3 per ADE detection when compared with a traditional chart review. It can therefore be seen that developing a computerized integrated system with professional intervention is essential for preventing ADEs cost-effectively.

An electronic ADE management system (EADES) to assist all health care providers in voluntary reporting and allow pharmacists to evaluate situations in a timely manner was implemented at Taipei Medical University—Wan Fang Hospital (WFH) in 2004. The purpose of this study was to evaluate the efficiency of the new system by comparing its outcomes with the traditional working model at WFH.

2. Methods

The present study compared the quantity and quality of ADEs occurring before and after the introduction of the EADES in Taipei Medical University—WFH. The detailed characteristics of ADEs were collected for 39 months before the deployment of EADES from November 1, 2000 to January 31, 2004. After the deployment, details of ADEs were again collected from February 1, 2004 to April 30, 2007. Before EADES was introduced, the ADE report cards were

placed on every ward for physicians, nurses, and pharmacists to voluntarily report ADEs in handwriting. Every reported case was evaluated by clinical pharmacists to ascertain the causes behind the suspected adverse drug reaction, and an investigation, including severity, causality and preventability, was conducted with a complete review of the appropriate literature.

EADES was established by integrating the following systems: (1) the emergency, inpatient, and outpatient computerized-order entry system; (2) the nursing care plan system; (3) the pharmacy system; and 4) the administration system. Figure 1 illustrates the process of EADES. The system allowed all medical staff, including physicians, pharmacists, and nurses, to report ADEs from every computer terminal in the hospital. When an ADE was reported to EADES, the information was saved in the central database and an email sent automatically to the pharmacist in-charge. Cases of ADEs were distributed to and evaluated by assigned pharmacists. Afterward, the assigned pharmacists sent evaluation reports to the central database, and electronic reminders were sent to the reporters to notify them of the results. The pharmacy department periodically organized meetings to discuss all confirmed severe ADEs. Special and sentinel cases were submitted to the ADE committee to determine potential prevention strategies. The system allowed

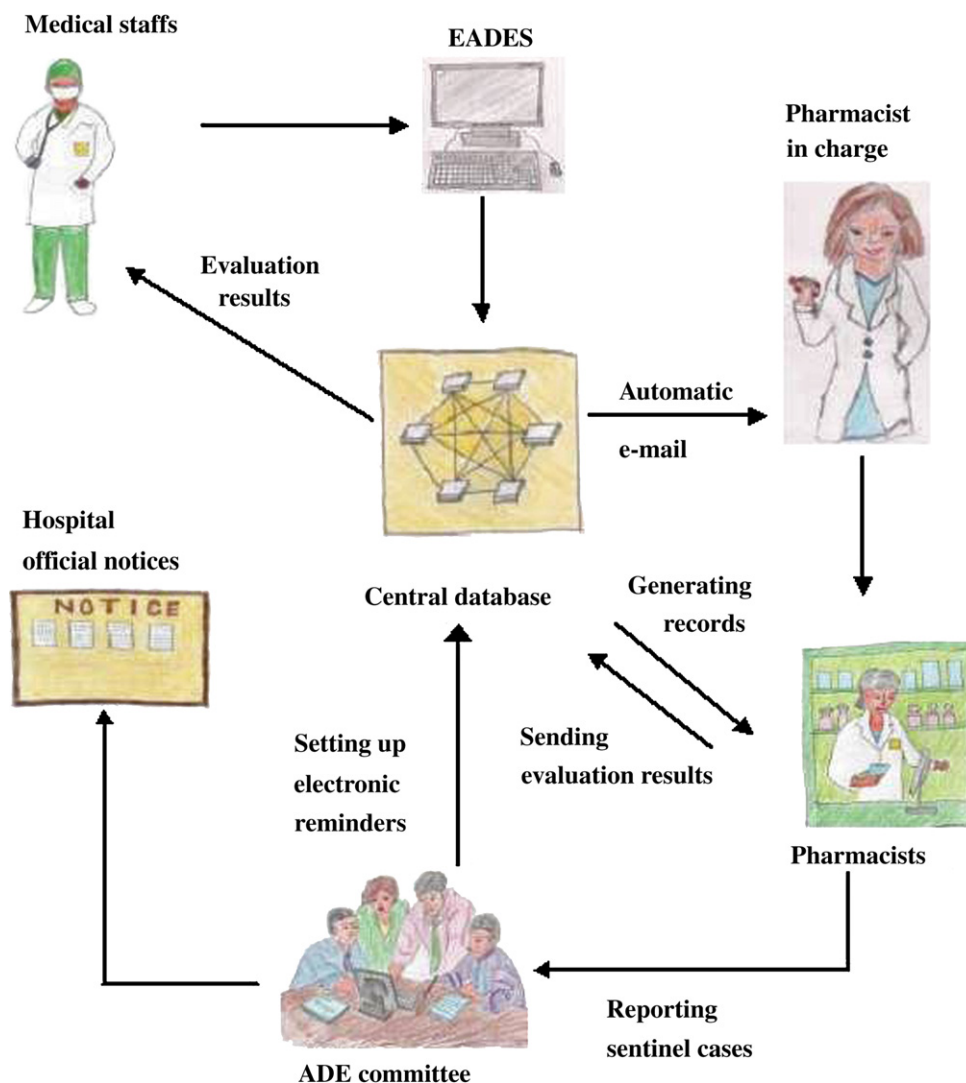


Figure 1 All data of the electronic adverse drug event management system (EADES) must be processed in the central database (Y.-H.Y. drew this figure and edited in Microsoft (R) Word 2000).

pharmacists to assess ADEs right after they were reported and electronically incorporate the evaluation results into a patient's allergy record to prevent reoccurrence of the same event.

The prevention function of the system is mainly concerned with drug allergies and cross-reactivity checking. Guidelines for the usage of medications with a high incidence of preventable ADEs, including nimodipine, hypnotic agents, and aminoglycosides, were generated. Sentinel cases were endorsed by the ADE committee, and approaches aimed at prevention of such ADEs were enforced throughout the hospital. Examples are shown in Table 1. These prevention strategies were therefore incorporated into the computerized physician order entry system and daily practice to avoid the recurrence of preventable ADE cases.

All ADE characteristics were compared using the χ^2 test. Data analyses were performed using SPSS version 10.0 (SPSS Inc., Chicago, IL, USA) for Windows. Statistical significance was defined as p value (two sided) <0.001 .

3. Results

The convenience brought about by EADES significantly increased ADE reports from 108 to 394 (Table 2), and the percentages of the medical staff who reported events were also changed significantly. The percentage of ADEs reported by doctors increased from 33% to 56%, the percentage reported by pharmacists fell from 67% to 26%, and those reported by nurses climbed from 0% to 18% ($p < 0.001$). Although the number of events reported by pharmacists increased with the introduction of EADES, the proportion of events reported by nonpharmacist staff also increased notably (Figure 2). It is also worth noting that the severity distribution of reported ADEs was significantly different between two reporting systems (Table 2). The proportion of minor ADEs was 12% before the introduction of EADES and 3% afterward. Additionally, the percentage of preventable ADEs decreased from 53% to 21% ($p < 0.001$).

There was a significant change in the distribution of reported medications (Table 3, $p < 0.001$). From 108 cases before the introduction of EADES, there were 30 cases of anti-infections (28%), 21 cases of antituberculosis agents (19%), and 5 cases of nimodipine (5%) of 7 cardiovascular agent-related events. However, the variety of reported medications increased significantly after the introduction of EADES (Figure 3, $p < 0.001$). With the new system, anti-infective agents were still the most frequently reported medications

Table 2 Reported ADEs before and after the introduction of EADES

ADE Characteristics	Before EADES, n (%)	After EADES, n (%)	p Value
ADE reports	108	394	
Characteristics			
Age (yr)			0.148
<2	0	5 (1)	
2–17	3 (3)	29 (8)	
18–40	25 (23)	99 (25)	
41–60	29 (27)	107 (27)	
61–80	34 (31)	119 (30)	
>80	17 (16)	35 (9)	
Female	47 (44)	197 (50)	0.233
Reporting medical staff			<0.001*
Doctor	36 (33)	222 (56)	
Pharmacist	72 (67)	100 (26)	
Nurse	0	72 (18)	
Causality by Naranjo score			0.389
Possible	45 (42)	177 (45)	
Probable	63 (58)	212 (54)	
Definite		5 (1)	
Level of severity			<0.001*
Minor	13 (12)	11 (3)	
Moderate	90 (83)	360 (91)	
Severe	5 (5)	22 (6)	
Fatal	0	1 (0.3)	
Preventability	57 (53)	84 (21)	<0.001*

ADE = adverse drug event; EADES = electronic adverse drug event management system.

* Statistically significant.

(98 cases, 25%); followed by nonsteroidal anti-inflammatory drugs (NSAIDs) (78 cases, 20%), cardiovascular agents (39 cases, 10%), and anticonvulsant agents (28 cases, 7%). Before the introduction of EADES, six NSAID-related cross-reactivity cases were reported; however, none of 78 NSAID cases reported afterward were of this nature. Additionally, no nimodipine-related ADEs were reported after the execution of the EADES preventive strategies.

4. Discussion

The results of the study reveal that ADE reports increased 3.6-fold. The proportion of nonpharmacist reporters, reported medications,

Table 1 Sentinel cases of adverse drug events and prevention approaches with dissemination of notices and standardization of processes

Examples of sentinel cases	Prevention approaches
Drug-induced renal failure - Aminoglycosides-induced acute renal failure occurred in several cases - Causes were long-term use, underline impaired renal function, volume depletion, concurrent use of nephrotoxic drugs, high peak and trough levels, previous exposure to aminoglycosides, and old age	- Development of computer-based system for drugs that need the dose adjusting for renal-impaired patients - Generating medication lists for pharmacists to intervene and follow up on
Unexpected sudden death - Haloperidol IM for a 56-year-old man because of agitation - Sudden death occurred 1 hr postinjection after episodes of tachycardia, heart failure, and respiratory failure	- Warning was added to computerized physician order entry system - Indicator was set for cautiously using haloperidol for elderly, physically debilitated, and agitated patients
Speed shock - Rapid cefazolin IV push for a 78-year-old female because of urinary tract infection - Patient suffered from hypotension, shortness of breath, and unconsciousness	- Cefazolin IV push was changed to IV drip, and the policy about the routes of IV agents was renewed - Pharmacy provided a list of agents suitable for IV push
Propofol infusion syndrome - Occurred 86 hr after infusion for a 24-year-old male admitted to ICU - Propofol infusion rate ≥ 5 mcg/kg/hr and duration ≥ 48 hr - Patient suffered from bradycardia, acidosis, hypotension, rhabdomyolysis, and acute renal failure	- Official notice was disseminated - Criteria were set to restrict infusion rate ≤ 5 mg/kg/hr and infusion time ≤ 48 hr

IM = intramuscular; IV = intravenous; ICU = intensive care unit.

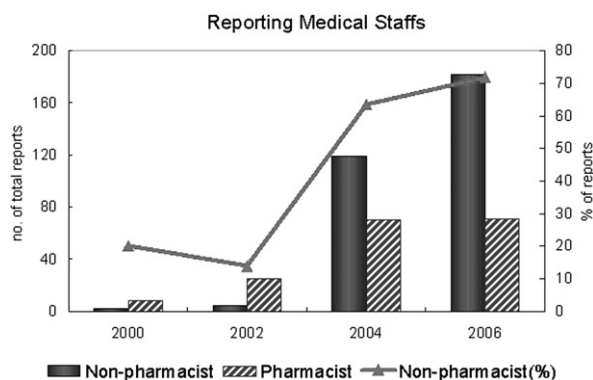


Figure 2 Trends in adverse-drug-event (ADE) reporting by physicians and nurses (■) and by pharmacists (▨). The electronic ADE management system was implemented in February 2004.

and ADEs were also significantly changed by the introduction of EADES. Moreover, the involvement of all health care providers also significantly increased. This transformation resulted in a distribution of reported medications and severity patterns of ADEs inline with expectations created by the available literature.^{5,11} Also, minor and preventable ADEs occurred less frequently, and the percentage of preventable ADEs decreased to 21%, which is similar to that reported in other literature.^{12,13} In addition, the system successfully reduced preventable cases involving a cross-reaction with NSAID by building allergy reminders into the computerized physician order entry system.¹⁴

The ease of use and convenience of the computerized system encourages all health care professionals to routinely practice ADE reporting in their clinical work.^{5,15} Before EADES was used, most ADEs were identified by pharmacists or physicians on the ADE committee. Because of this, most ADEs were reported from certain classes of medications. For example, the antituberculosis medications were reported at a higher percentage rate (19%) because of one pulmonologist being active on the ADE committee. Also nimodipine-induced abnormal liver function tests constituted most reported cardiovascular agents by pharmacists. Some commonly occurring ADEs were never reported before EADES, such as dry cough because of angiotensin-converting enzyme inhibitor¹⁶ and myopathy or hepatitis caused by 3-hydroxyl-3-methyl-glutaryl-coenzyme A inhibitor.¹⁶ After EADES was used, the change in distribution of those submitting reports and the variety of reported

Table 3 Pharmacologic classifications of the reported ADEs

Reported medications	Before EADES (n = 108), n (%)	After EADES (n = 394), n (%)	p Value
Antibiotics	30 (28)	98 (25)	<0.001*
Analgesics	14 (13)	78 (20)	
Cardiovascular	7 (7)	39 (10)	
Anticonvulsants	9 (8)	28 (7)	
Central nervous system	4 (3)	21 (5)	
Gastrointestine	2 (2)	20 (5)	
Antituberculosis	21 (19)	18 (5)	
Agents used for diagnosis	1 (1)	17 (4)	
Anticoagulant/antiplatelet	6 (5)	16 (4)	
Antipsychotics/antidepressants	2 (2)	14 (3)	
Antineoplastics	2 (2)	11 (3)	
Antihyperglycemics	3 (3)	7 (2)	
Others	7 (7)	27 (7)	

ADE = adverse drug event; EADES = electronic adverse drug event management system.

* Statistically significant.

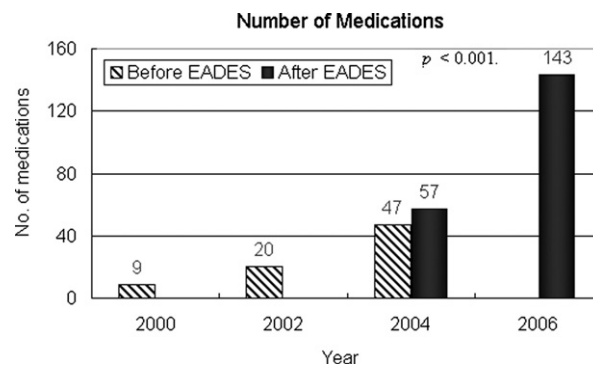


Figure 3 The number of medications before the introduction of EADES (▨) and after the introduction of EADES (■). EADES = the electronic adverse drug events management system.

medications indicate that EADES improved the practice of reporting ADEs in WFH.

The reporting of ADEs was also encouraged by a nonpunitive reward program: each person submitting a report would be rewarded with about USD\$3 (NT\$100) for each case. This study indicates that a nonpunitive and voluntary ADE reporting system results in better information than a mandatory system,³ and that it can be used as a key tool to enhance awareness and proactive participation in health care quality and safety initiatives.¹⁵ Jointly, the electronic system and nonpunitive program engendered a positive ADE-reporting culture and managed ADEs effectively without causing communication barriers between areas of specialties.

The limitation of this study is that the voluntary use of EADES may underestimate the rate of ADEs when compared with a signal alerting ADE system.^{17,18} Although many new methods, such as signal detections and data mining, have shown benefits in ADE prevention, voluntary reporting remains an indispensable data source for postmarket surveillance analysis.¹⁹ It was also proven that it could detect a wider variety of ADEs compared with fixed signal ADE detection.²⁰ By combining the benefits of voluntary reporting and newer technologies, for instance an ADE alert signal approach, EADES will be upgraded in future to detect and prevent more ADEs in advance.

5. Conclusion

The EADES not only significantly improved the ADE reporting culture in the hospital but also proved to be an efficient tool for managing ADEs for all health care professionals. With EADES, pharmacists are able to assess any reported ADE and give feedback in a timely fashion. We will proactively and continuously update the system to fit the future demands of ADE management in facilitating patient safety.

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References

- Ortega A, Aguinagalde A, Lacasa C, Aquerreta I, Fernandez-Benitez M, Fernandez LM. Efficacy of an adverse drug reaction electronic reporting system integrated into a hospital information system. *Ann Pharmacother* 2008;**42**: 1491–6.
- Lee SB, Schepers GP, Goldberg KL. Electronic adverse-drug-reaction-reporting program. *Am J Health Syst Pharm* 2004;**61**: 1230, 1232–3.

3. Kunac DL, Harrison-Woolrych M, Tatley MV. Pharmacovigilance in New Zealand: the role of the New Zealand Pharmacovigilance Centre in facilitating safer medicines use. *N Z Med J* 2008;**121**:76–89.
4. Jha AK, Kuperman GJ, Rittenberg E, Teich JM, Bates DW. Identifying hospital admissions due to adverse drug events using a computer-based monitor. *Pharmacoepidemiol Drug Saf* 2001;**10**:113–9.
5. Jha AK, Kuperman GJ, Teich JM, Leape L, Shea B, Rittenberg E, Burdick E, et al. Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report. *J Am Med Inform Assoc* 1998;**5**:305–14.
6. Leape LL, Cullen DJ, Clapp MD, Burdick E, Demonaco HJ, Erickson JI, Bates DW. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. *JAMA* 1999;**282**:267–70.
7. Schnipper JL, Kirwin JL, Cotugno MC, Wahlstrom SA, Brown BA, Tarvin E, Kachalia A, et al. Role of pharmacist counseling in preventing adverse drug events after hospitalization. *Arch Intern Med* 2006;**166**:565–71.
8. Murray MD, Ritchey ME, Wu J, Tu W. Effect of a pharmacist on adverse drug events and medication errors in outpatients with cardiovascular disease. *Arch Intern Med* 2009;**169**:757–63.
9. Anderson JG, Jay SJ, Anderson M, Hunt TJ. Evaluating the capability of information technology to prevent adverse drug events: a computer simulation approach. *J Am Med Inform Assoc* 2002;**9**:479–90.
10. Hope C, Overhage JM, Seger A, Teal E, Mills V, Fiskio J, Gandhi TK, et al. A tiered approach is more cost effective than traditional pharmacist-based review for classifying computer-detected signals as adverse drug events. *J Biomed Inform* 2003;**36**:92–8.
11. Hwang SH, Lee S, Koo HK, Kim Y. Evaluation of a computer-based adverse-drug-event monitor. *Am J Health Syst Pharm* 2008;**65**:2265–72.
12. Rothschild JM, Federico FA, Gandhi TK, Kaushal R, Williams DH, Bates DW. Analysis of medication-related malpractice claims: causes, preventability, and costs. *Arch Intern Med* 2002;**162**:2414–20.
13. Gandhi TK, Weingart SN, Borus J, Seger AC, Peterson J, Burdick E, Seger DL, et al. Adverse drug events in ambulatory care. *N Engl J Med* 2003;**348**:1556–64.
14. Bates DW, Leape LL, Cullen DJ, Laird N, Petersen LA, Teich JM, Burdick E, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA* 1998;**280**:1311–6.
15. Wu JH, Shen WS, Lin LM, Greenes RA, Bates DW. Testing the technology acceptance model for evaluating healthcare professionals' intention to use an adverse event reporting system. *Int J Qual Health Care* 2008;**20**:123–9.
16. Dukes MNC, Aronson JK. *Meyler's Side Effects of Drugs*. Amsterdam: Elsevier; 2000. 638–55 and 1527–37.
17. Thurmann PA. Methods and systems to detect adverse drug reactions in hospitals. *Drug Saf* 2001;**24**:961–8.
18. Kilbridge PM, Campbell UC, Cozart HB, Mojarrad MG. Automated surveillance for adverse drug events at a community hospital and an academic medical center. *J Am Med Inform Assoc* 2006;**13**:372–7.
19. Ye X, Fu Z, Wang H, Du W, Wang R, Sun Y, Gao Q, et al. A computerized system for signal detection in spontaneous reporting system of Shanghai China. *Pharmacoepidemiol Drug Saf* 2009;**18**:154–8.
20. Waller PC. Making the most of spontaneous adverse drug reaction reporting. *Basic Clin Pharmacol Toxicol* 2006;**98**:320–3.