Patient safety is an area of continuing educational need for healthcare providers that has become a global research priority [1], and in the United States, the Federal Drug Administration (FDA) initiated a national Safe Use Initiative [4]. Among the most common medical errors that erode patient safety are medication errors, a leading cause of death and harm affecting an estimated 1.5 million people annually in the United States alone [2,3]. The urgency of the educational need is evident from the enormous burden of 400,000 preventable, drug-related injuries with additional costs of $3.5 billion to hospitals, and an additional 800,000 preventable drug-related injuries in long-term care settings [3]. Furthermore, the National Electronic Injury Surveillance System indicated that adverse drug experiences (ADEs) accounted for as much as 35% of emergency department visits for all unintentional injuries [5]. This burden on both patients and society highlights a need to improve provider practices [3].

Successful improvements in hospitals include computerized physician order entry [6], black box warning alerts in the electronic health record [7], implementation of bar coding [8,9], and use of smart pumps [10]. However, the prevalence of medication errors and drug-related injuries are also high in ambulatory care, and the need for improvement crosses all practice settings [11-13].

As a remedy, education is recommended in the National Patient Safety Goals from the Joint Commission to improve the effectiveness of caregiver communication and safe medication use [14]. As a method of education, evaluations show that internet-based learning is associated with positive effects compared with no intervention, and compared with other formats [15-18]. A recent meta-analysis demonstrated effectiveness of multi-component internet educational
curricula in changing healthcare provider practice patterns and in improving their medical knowledge [19].

The objective of this study was to evaluate the effectiveness of an internet continuing education (CE) curriculum on safe medication use [20-24] by measuring medication risk-reducing choices of healthcare providers in response to patient case vignette surveys.

MATERIALS AND METHODS

To evaluate the effectiveness of an accredited internet CE curriculum on safe medication use, a patient vignette outcomes study was used for high-level outcomes [25]. The evaluation plan was to compare responses of healthcare providers who participated in the curriculum immediately following CE with a similar group of healthcare professionals who did not participate, using a case-controlled design (Figure 1). Prior to initiation of this study, the case vignette study design was reviewed by the Western Institutional Review Board (WIRB; Olympia, WA) and approved December 2004.

The internet curriculum content was based on gaps identified in a needs assessment. The curriculum content was created by interdisciplinary faculty including physician, nursing, and pharmacy experts. It was delivered in multimedia, interactive formats and offered free of charge by internet access. Each activity in the curriculum was certified by Medscape for credit for physicians, nurses, and pharmacists;

![Diagram](image)

**Figure 1.** A case-controlled design was planned and implemented as diagrammed. The survey instrument was a brief, patient case vignette–based survey. The responses of a random group of healthcare providers who participated in the continuing education (CE) curriculum were compared with a similar group of healthcare providers who did not participate.

<table>
<thead>
<tr>
<th>Table 1. Healthcare Provider Participants in 5 Internet Educational Activities [21-25]*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational Activity</strong></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>1. Drug mix-ups threaten patient safety. Interactive clinical case, 1 credit hour.</td>
</tr>
<tr>
<td>2. Communicating drug risks to patients. Interactive clinical review, 1 credit hour.</td>
</tr>
<tr>
<td>3. The astute clinician: filing high-value ADE reports. Lecture with slides and transcript, 1 credit hour.</td>
</tr>
<tr>
<td>5. Teaming up to prevent ADE. Video roundtable with slides and transcript, 0.5 credit hours.</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*The educational activity title, format description, and total amount of credit hours available to each participant and total completions are shown. Activities were available from the dates shown until April 2009 when data were collected for analysis. CME indicates continuing medical education credits for physicians; CE, continuing education credits for nursing and pharmacists; LOC, letter of completion for credits for other healthcare professionals such as physician assistants; ADE, adverse drug experience.
CE continuing education credit for nurses and pharmacists; CME continuing medical education credit for physicians; and letter of completion (LOC) credit for other healthcare professionals including physician assistants (PAs) and others. It was an interprofessional curriculum, designed to educate and evaluate the broad healthcare team.

The content of 5 CE activities was included in the outcomes study, and each activity was available for up to 0.5 or 1 hours of credit per activity (Table 1) [21-25]. The multimedia formats used to present the content included interactive clinical cases and interactive clinical review, video lecture, and video roundtable with slides and transcripts. All activities were available beginning in 2008, and data were collected in April 2009 (Table 1). To reach participants, the internet activities within the curriculum were tagged with keywords to facilitate online searching. Participants were also recruited to participate by emailed newsletters and by placement of a link to the curriculum in an internet destination, the Adverse Drug Event Reporting Resources Center.

The outcomes study group was planned to include at least 100 interdisciplinary CE participants randomly selected from each of 5 CE activities in the curriculum to generate a large enough sample for statistically significant results. Based on the participant demographic characteristics, the control group was randomly selected from non-participant healthcare providers to enable extrapolation of results to the whole. Participants and controls were matched by profession, specialty, years in practice, and patient load. Controls were identified from each group’s affiliated professional society database and contacted by email and fax, including at least 100 for each activity. For activity 1, the study included primary care physicians, nurse practitioners (NPs), and pharmacists. In activity 2, the study included primary care physicians and NPs. For activity 3, the study included family physicians, pediatricians, NPs, and PAs. In activity 4, the study included pharmacists, NPs, and nurses. The activity 5 study included primary care physicians and nurses.

All data collected following CE and from controls was de-identified and analyzed in aggregate to maintain confidentiality of all participant information. Patient case vignettes were the clinical basis of each survey. Studies have shown patient
vignettes to be comparable to patient chart reviews but without the inter-patient variability [27-29]. The vignettes were followed by a 7- to 10-question survey in multiple-choice format. Questions were based on performance indicators related to the CE learning objectives and referenced to FDA guidelines and the recommendations of the National Coordinating Council for Medication Error Reporting and Prevention (Table 2) [30,31].

For data extraction, transformation, and statistical analyses, statistical analysis a SAS 9.1.3 software package was used (SAS Institute Inc., Cary, NC, USA). Overall mean scores were calculated and t test scores calculated to compare the means. Pooled standard deviations were calculated for participant and control groups for each activity, in concordance with evidence-based and referenced educational activity content. Because a comparison group was used, Cohen’s d formula was selected (ie, the difference in mean divided by the square root of the pooled standard deviation) to determine the average differences between 2 groups—participants and controls—and to determine the educational effect size [30]. Percentage of non-overlap shows differences in the likelihood of making appropriate choices as the percent likelihood of improved practice.

### RESULTS

Overall, 63,612 CE posttest completions to claim CME, CE, or LOC credits were recorded by healthcare providers who participated in this educational curriculum focused on safe use of medication (Table 1). Overall, 17,424 physicians, 29,989 nurses and NPs, 7853 pharmacists, and 4624 allied healthcare providers including PAs completed the curriculum for credit. These participation demographics show that the curriculum reached the broad, interdisciplinary healthcare team.

Performance items selected as indicators of safe medication use for the outcomes study participants and controls (N = 1017), are shown in Table 2. These included recognizing and reducing drug “look-alike, sound-alike” (LASA) errors, asking patients to “teach-back” prescription directions, the correct reporting mechanisms established for ADEs, and the use of positive de-challenge to identify the drug associated with a reaction [30,31]. The proportion of appropriate responses were significantly higher among participants (n = 511) than controls (n = 506) for 7 of the 8 performance items (Table 2). The largest increases were use of positive de-challenge to identify the medication and the reporting of medication errors and of adverse events to the ISMP (P < .001 for each). In addition, large increases in reporting ADEs to FDA MedWatch were seen (P = .001). Only 20% of CE participants and 16% of controls identified that a report of an ADE to a local pharmacist would not lead to mandatory reporting of the event (P = .5). This may be due to unclear wording of the question. The effective patient communication technique of having a patient “teach-back” prescription information to the healthcare provider significantly increased among participants compared with controls (P = .02) (Table 2).

The effect sizes calculated for each of the activities show moderate to large positive effects and ranged from 0.48 to 0.92 (Table 3). Positive effects in the moderate range were seen for the 4 activities focused on drug-drug interactions, drug mix-ups, and communicating with the healthcare team and patient. A large positive effect size of 0.92 was seen for the activity focused on appropriate and effective filing of ADE reports. Percentage of non-overlap between participants and controls was 32% to 52%. This indicates differences between participants and controls in the likelihood of making appropriate clinical choices, reflecting a likelihood of improved practices (Table 3).

In addition to CME posttests and the outcomes study survey, participants in the outcomes study (N = 1017) reported barriers they most frequently encounter in their

### Table 3. Effect Size Comparing Participants versus Controls in 5 Educational Activities [21-25]*

<table>
<thead>
<tr>
<th>Educational Activity</th>
<th>Participant, n</th>
<th>Control, n</th>
<th>Mean Appropriate Response of Participants</th>
<th>Mean Appropriate Response of Controls</th>
<th>P</th>
<th>Effect Size (Cohen’s d)</th>
<th>% of Non-overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug mix-ups threaten patient safety</td>
<td>100</td>
<td>100</td>
<td>76.0%</td>
<td>65.7%</td>
<td>&lt;.001</td>
<td>0.59</td>
<td>38%</td>
</tr>
<tr>
<td>Communicating drug risks to patients</td>
<td>103</td>
<td>98</td>
<td>72.4%</td>
<td>60.2%</td>
<td>&lt;.001</td>
<td>0.72</td>
<td>44%</td>
</tr>
<tr>
<td>The astute clinician: filing high-value ADE reports</td>
<td>100</td>
<td>98</td>
<td>57.7%</td>
<td>44.0%</td>
<td>&lt;.001</td>
<td>0.92</td>
<td>52%</td>
</tr>
<tr>
<td>Managing drug-drug interaction risks</td>
<td>100</td>
<td>101</td>
<td>54.6%</td>
<td>45.6%</td>
<td>&lt;.001</td>
<td>0.48</td>
<td>32%</td>
</tr>
<tr>
<td>Teaming up to prevent ADEs</td>
<td>108</td>
<td>108</td>
<td>76.1%</td>
<td>64.5%</td>
<td>&lt;.001</td>
<td>0.66</td>
<td>41%</td>
</tr>
</tbody>
</table>

*Cohen’s d, the difference in mean divided by the square root of the pooled standard deviation, was used to determine the educational effect size as the average differences between 2 groups, participants in continuing education and controls [30]. Percentage of non-overlap shown indicates differences in the likelihood of making appropriate choices. ADE indicates adverse drug experience.
own practices related to improving safe medication use. For participants in activity 1, the barrier most frequently reported by the outcomes study group (n = 108) was that of inadequate communication within the healthcare team. This barrier was cited by 45% overall: 53% of pharmacists, 43% of nurses, 39% of physicians, and 35% of NPs. Inadequate patient counselling on prescribed medications was the second most cited barrier, cited by 41% of NPs, 36% of physicians, 33% of nurses, and 27% of pharmacists. The educational activities addressed reporting recommendations as well as patient and interprofessional communication techniques in a patient case study.

For participants in activity 5, the most frequently cited barrier in the outcomes study group (n = 108) was ineffective communication among healthcare professionals and with patients, by 85% of pharmacists, 70% of NPs, 61% of nurses, and 55% of physicians. (Figure 2). This educational activity addressed both interprofessional and patient communication techniques as a video roundtable discussion. The results indicate that communication barriers are commonly experienced in the healthcare providers’ practices, across disciplines.

**DISCUSSION**

Education of healthcare providers is an important area of focus to raise the bar in building a culture of safety [3]. The FDA recently began the Safe Use Initiative to focus on preventable medication risks as a public health imperative [4]. In this report of an interprofessional outcomes study, healthcare providers who completed internet CE on safe use demonstrated statistically significantly higher scores on measures of performance than their matched controls. The average effect size for the 5 CME/CE activities was 0.68, demonstrating a positive effect in the higher end of the moderate range (0.4 to 0.8). Higher scores among participants compared with controls were seen across disciplines (physicians, NPs, nurses, pharmacists, and PAs) in the important areas of preventing, detecting, and reporting ADEs. These correspond to several touch-points in the inter-related system of safe medication use (Figure 3).

A limitation of this study is the collection of data immediately following the educational intervention; therefore, long-term effects were not measured. This is an important area for future study. Another potential limitation is use of healthcare providers’ self-reported information, which may be biased toward socially desirable responses. However, the large gaps between recommended practices and the practices reported indicate that participants did not strictly select the socially desirable responses.

A strength of the study is participation by large numbers of clinicians (N = 63,612) in the CE curriculum and in the outcomes study (N = 1017). A second strength is the inclusion of the broad healthcare team (physicians, NPs, nurses, pharmacists, and PAs) in the curriculum and in the outcomes study. In addition, the use of methods for education which were previously shown to be the most effective [19], including multimedia, interactive formats for CE activities, and multiple exposures, also strengthens the study.

The CE curriculum fostered adoption of safety-enhancing strategies for communication with patients, as assessed with patient case–based surveys in the outcomes study. Enhanced communication reduces risk for 2 failure modes: faulty transmission of high-stakes data and failure to engage patients to maximize self-advocacy and adherence [32].

**Figure 2.** Continuing education (CE) participants in the outcomes study (n = 108) of activity 5 were asked to report the barriers to safe use that they most frequently encounter in their own practices. Each participant could select multiple responses among the choices of communication with healthcare providers and patients, knowledge of drug, resources available, and time constraints. The percentage of each response selected is shown for each healthcare provider professional group. HCP indicates healthcare practitioner; NP, nurse practitioner.
Nurses, the healthcare providers who most often administer drugs and monitor effects in inpatient settings, are most likely to uncover errors [33]. Our data indicate a high level of sensitivity among nurses regarding communication deficits, as well as among other providers. Both nurse and physician participants identified communication gaps as the most significant barrier to working effectively as a team and to improving practice.

Notably, many respondents consider few of their patients to be at risk for LASA errors, indicating a low level of awareness of this problem [14]. Specific examples of drug nomenclature provided in the CE activities provided participants with the scientific rationale behind recommended practice changes. Participants learned that name confusions should be reported to the ISMP. Engaging patients early in the medication use process when the prescription is written and stressing drug name, dose, and purpose of the medication can promote provider–patient dialogue. In this study, participants more often selected the strategy of having patients “teach-back” safety-sensitive drug information, compared with controls. This is an important and effective tool to improve communication.

CE participants learned the importance of sharing medication errors with the ISMP, which may lead to increased learning and sharing of error information on a national scale. One of the new, effective ways of improving reporting is mandatory reporting linked to the electronic record [34]. The public health effects that may follow from safer practices among CE participants in this curriculum are potentially wide reaching. Considering the more than 60,000 participants, and the multiple patients those participant healthcare providers see each year, projected benefits may touch millions if not tens of millions of patient encounters yearly.

In conclusion, for their continuing professional development, healthcare providers need interprofessional resources to learn safe medical practices and reduce medication errors. CE participation is one of the tools to improve healthcare provider practices in safe use of medication; however, more resources and tools are clearly needed in this area.

ACKNOWLEDGMENT
The educational activities and outcomes study were supported by an independent educational grant from the Pharmaceutical Research and Manufacturers of America (PhRMA).

REFERENCES


