

# Assessing the Accuracy of Drug Profiles in an Electronic Medical Record System of a Washington State Hospital

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**P**atient safety is widely recognized as an important public health concern.<sup>1</sup> Research studies document that a significant number of patients experience adverse health events when receiving care<sup>2-4</sup> and that medication errors constitute the most common type of adverse event in inpatient and ambulatory settings.<sup>1</sup> Understanding the nature and frequency of medication errors is important for evaluating the effectiveness of safety strategies such as medication reconciliation programs,<sup>5,6</sup> computerized prescribing,<sup>7</sup> bar code technology,<sup>8</sup> Web-based patient portals linked to electronic health records (EHRs),<sup>9</sup> and computerized provider entry with clinical decision support systems.<sup>10</sup>

In 1999, the Veterans Health Administration (VHA) established an electronic medical record (EMR) system in all VHA hospitals that contains pharmacy data and patient demographic information such as age and copayment status.<sup>11</sup> Their EMR system has the capacity to reduce risks of medical errors in patient care by providing real-time drug profiles to all Veterans Affairs Medical Centers (VAMCs), regardless of geographic location.<sup>11</sup> However, reducing adverse drug events (ADEs) and adverse drug reactions (ADRs) has proved more difficult than even defining ADEs and ADRs.<sup>12</sup>

In a prospective observational study, Pippins et al<sup>6</sup> examined the cause, timing, and key predictors of potentially harmful inpatient medication discrepancies. The authors identified 2066 errors of medication reconciliation among 180 patients and reported that 257 medication discrepancies (12.4%) were unintentional and were potentially harmful to the patient. Poor patient understanding about preadmission medications, the number of medication changes from preadmission to discharge, and medication history taken by an intern were found to be associated with potential ADEs. To improve medication safety during and after hospitalization, the authors recommended focusing on accurate medication histories, potential medication errors at discharge, and identification of high-risk patients for more intensive interventions.

Gandhi et al<sup>7</sup> studied medication errors, potential ADEs, and preventable ADEs and the effect of computerized prescribing at 4 adult primary care practice sites in the Boston, Massachusetts, area. They screened

1879 prescriptions among 1202 patients and completed 661 surveys. Their results indicated that 7.6% of outpatient prescriptions contained an error, and many

**Objectives:** To determine the accuracy of patients' electronic medical record (EMR) drug profiles, to assess the relationship of copayment status with errors of commission and omission within drug profiles, and to evaluate the association between errors of commission in primary and secondary sections of the drug profiles.

**Study Design:** Cross-sectional analysis of patients' EMR drug profiles at a 46-bed hospital in Washington state.

**Methods:** Patients' drug profiles were compared against hospital staff interviews. Drug profiles listing each medication the patient was taking, without listing drugs the patient was not taking, exhibited perfect accuracy. We evaluated associations between errors of commission and omission, copayment status between errors of commission and omission, and associations between errors of commission in primary and secondary sections of the drug profiles.

**Results:** Demographics of study patients are similar to previously published research, and accuracy outcomes seem to be better than those of previously published studies. Fifty-six percent of drug profiles in our study hospital exhibited perfect accuracy. Errors of commission and omission were unassociated with copayment status; errors of commission in the primary section of the drug profile were unassociated with errors of commission in the secondary section of the drug profile.

**Conclusions:** A medication reconciliation program may have led to a high rate of perfectly accurate drug profiles; while its purpose is to increase accuracy and to decrease errors, it may also assist in reducing adverse drug events. Results show that copayment amounts influence drug utilization; these may be associated with errors of commission and omission and not simply with copayment status.

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### Take-Away Points

For many healthcare entities, the first step to increasing quality of care is the use of an electronic medical record (EMR). As our study discovered, infrastructure improvements by themselves are fallible and must be complemented with process improvements such as a medication reconciliation program.

- Healthcare decision makers must not rely solely on technology to improve patient care.
- An EMR system coupled with a medication reconciliation program yielded more accurate drug profiles.
- A comprehensive and accurate EMR drug profile may reduce the risk of an adverse drug event and may increase providers' prescription options for their patients.

mistakes could have harmed patients. The authors concluded that basic computerized prescribing systems may be inadequate to reduce errors, and they suggested that more advanced systems with dosage and frequency checking are needed to prevent potentially harmful errors.

Poon et al<sup>8</sup> investigated whether implementation of bar code technology reduced dispensing errors and potential ADEs in an inpatient setting. The authors performed a before-and-after evaluation study over a 20-month period in a 735-bed tertiary care academic medical center. The authors reported that the overall rates of dispensing errors and potential ADEs were substantially reduced after implementation of the bar code technology but noted that the technology needs to be configured to scan every dose during the dispensing process.

Schnipper et al<sup>9</sup> reported on the preliminary results of the Patient Gateway medications module, a patient portal linked to an EHR. The authors hypothesized that the module would facilitate patient-provider communication and increase the documentation of medications and allergies within the Partners HealthCare (Boston, Massachusetts) EHR, as well as improve the detection and handling of discrepancies and ADEs, patient knowledge of and adherence with their medications, and patient satisfaction with care. According to preliminary use and satisfaction data, patients found the module easy to use and believe that the portal allowed their providers to have more accurate information about them and enabled them to feel more prepared for their future visits. However, the effects of this intervention on various medication-related outcomes have not been documented to date.

Using a cluster randomized controlled trial, Gurwitz et al<sup>10</sup> evaluated the efficacy of computerized provider order entry with clinical decision support for preventing ADEs in a long-term care setting. The authors screened 29 resident care units, each with computerized provider order entry, that were randomized to having a clinical decision support system or not. Based on their study results, the authors reported that computerized provider order entry with decision support did not decrease the ADE rate or preventable ADE rate in the

study setting. They concluded that alert burden, limited scope of the alerts, and a need to more fully integrate clinical and laboratory information may have affected the efficacy of the computerized provider order entry with a clinical decision support system.

Two studies<sup>5,13</sup> assessed VHA EMR drug profile accuracy. Hsia and colleagues<sup>13</sup> noted that discrepancies in patient drug profiles decreased significantly

after continued interviews with patients to update their EMR drug profiles. Kaboli and colleagues<sup>5</sup> found few perfect matches between patients' current drug regimens and what their EMR listed as current: only 5.3% of 493 drug profiles examined were perfectly accurate.

A low percentage of perfectly accurate EMR drug profiles may lead to ADEs.<sup>5</sup> According to Weir et al, inpatients who experience an ADE "may have up to a 2-fold [increased] risk of death."<sup>14(p39)</sup>

Kaboli and colleagues<sup>5</sup> provide the following 2 explanations for discrepancies found in their study between what was listed in EMR drug regimens and what the hospital believed the patient was taking: (1) VHA prescriptions were stopped by non-VHA physicians without updating the patient's EMR drug profile (error of commission) and (2) non-VHA medication regimens were started without their being entered into the patient's EMR drug profile (error of omission). Errors of commission can lead to false restriction of drugs that a VHA provider can choose to prescribe for a patient after reviewing listed current drugs that the patient is not actually taking. Errors of omission can lead to an ADE when newly introduced drugs react with a current drug that the patient is taking but of which the provider is unaware. This study attempts to answer some of the questions that Kaboli and colleagues raise from their study results.

Objectives of the present study were several. To better address patient safety, we determined the accuracy of patients' EMR drug profiles at a 46-bed hospital in Washington state that uses a medication reconciliation program aimed at reducing ADEs, assessed the relationship of copayment status with errors of commission and omission within drug profiles, and evaluated the association between errors of commission in primary and secondary sections of the drug profiles.

## METHODS

Electronic medical record drug profiles were examined at a 46-bed hospital in Washington state that treats more than 11,000 patients per year and uses a medication reconcilia-

■ **Table 1.** Errors of Commission and Omission Within Copayment Groups

Drug Profile Data	Copayment (n = 124)	No Copayment (n = 64)	P <sup>a</sup>
<b>Drug profiles with perfect accuracy, No. (%)</b>	71 (57.3)	35 (54.7)	
<b>No. of Drugs listed</b>			
Total No.	1167	774	—
Mean No. per patient	9.4	12.1	<.001
<b>No. of Errors of commission</b>			
Mean No. per patient	0.6	0.5	.96
Drug errors, No./total No. (%)	76/1167 (6.5)	32/774 (4.1)	—
<b>Current regimen drugs listed</b>			
<b>Total No.</b>	1149	755	—
Mean No. per patient	9.3	11.8	<.001
<b>No. of Errors of omission</b>			
Mean No. per patient	0.5	0.2	.19
Current regimen drug errors, No./total No. (%)	58/1149 (5.0)	13/755 (1.7)	—

<sup>a</sup>By Mann-Whitney test, the nonparametric equivalent of *t* test.

tion program. To mirror the study in an Iowa City VAMC by Kaboli et al<sup>5</sup> (hereafter Iowa City VAMC), a cross-sectional design was used to select patients from 1 of 3 family medicine outpatient clinic teams for inclusion during the spring of 2006; patients were 65 years or older and were using 5 or more drugs (excluding topical ointments). The drug profiles included inpatient and outpatient prescriptions. As in the Iowa City VAMC, drugs were defined as a prescription medication, an over-the-counter product, or a vitamin, herb, or mineral recorded on the drug profile of a patient at the time of his or her appointment.

Before seeing his or her provider, a 1-year drug history from the patient's EMR was reviewed with a clinical staff member, who followed a strict protocol. This constituted the medication reconciliation process at the study hospital. Each medication on the list was reviewed with the patient to determine if it was still being taken. If not, a note was made on the list, and any drugs not being taken were removed from the patient's EMR drug profile. The 1-year historical list contained 2 sections: the primary section lists drugs prescribed by the study hospital, and the secondary section listed drugs obtained outside of the study hospital (eg, prescribed by other providers or obtained over the counter, etc). At the conclusion of each interview, the patient was asked if he or she was taking any medications not on the 1-year historical list; if so, those drugs were added to the patient's EMR drug profile. Our study data were drawn from printed copies of these 1-year historical patient drug lists, complete with notes from the interviewer.

Patient age, copayment status (recorded as yes or no), the number of current regimen drugs, and the total numbers of er-

rors of commission and omission in each patient's EMR drug profile were recorded. From the data, we calculated the mean age of the sample, the mean number of drugs per EMR drug profile, the percentage of patients with a copayment for their prescriptions, the percentage of EMR drug profiles that exhibited perfect accuracy, the mean numbers of errors of commission and omission per drug profile, and the percentage of errors of commission and omission relative to the total number of drugs a patient was taking. We also performed a statistical analysis of errors of commission and omission according to copayment status.

All statistical calculations were conducted using Analyse-it (Leeds, England),<sup>15</sup> which uses C++ programming language as opposed to spreadsheet algorithms. The statistical results obtained with Analyse-it provide a higher degree of accuracy than other commercially available software programs.

## RESULTS

Our study evaluated drug profiles of 200 patients (mean [SD] age, 75 [6.6] years); 62.0% had a copayment and 32.0% did not (12 EMRs did not list a copayment status). The mean (SD) number of medications listed per EMR drug profile was 10.4 (4.0), and the total number of drugs recorded was 2086. The total numbers of drugs listed were 1824 in primary sections of the drug profiles and 262 in secondary sections. The mean numbers of drugs listed were 9.12 in primary sections of the drug profiles and 1.31 in secondary sections. The total number of current regimen drugs was 2045, resulting in a mean (SD) of 10.2 (4.0) current

■ **Table 2.** Errors of Commission and Omission Associated With Copayment Status

Variable	Copayment	No Copayment	P <sup>a</sup>
<b>No. of errors of commission</b>			
Total	76	32	—
Mean	0.6	0.5	.96
<b>No. of errors of omission</b>			
Total	58	13	—
Mean	0.5	.02	.19

<sup>a</sup>By Mann-Whitney test, the nonparametric equivalent to *t* test.

■ **Table 3.** Errors of Commission in Primary and Secondary Sections of the Electronic Medical Record Drug Profiles

No. of Errors of Commission	Primary Section <sup>a</sup>	Secondary Section <sup>b</sup>	P <sup>c</sup>
Total	89	29	—
Mean	0.4	0.1	.15

<sup>a</sup>Lists drugs prescribed by the study hospital.  
<sup>b</sup>Lists drugs obtained outside of the study hospital.  
<sup>c</sup>By Spearman rank correlation test, the nonparametric equivalent to Pearson product moment correlation test.

regimen drugs per patient. The percentage of EMR drug profiles that exhibited perfect accuracy was 56.0%. Of 112 patients with perfectly accurate drug profiles, 71 (63.4%) had a copayment, and 35 (31.3%) did not (6 did not list a copayment status). Therefore, 57.3% of patients with a copayment and 54.7% of patients without a copayment had perfectly accurate drug profiles (Table 1).

The total number of errors of commission among the study sample was 118, a mean (SD) of 0.6 (1.1) per patient. Using the total number of errors of commission as the numerator and the total number of drugs listed as the denominator, 5.7% of medications in the EMR drug profiles were not actually being taken. The total number of errors of omission among the study sample was 77, a mean (SD) of 0.4 (1.0) per patient. Using the total number of errors of omission as the numerator and the total number of drugs being taken as the denominator, 3.8% of the total number of current regimen drugs were not listed in the EMR drug profiles. No dependent variables exhibited a normal distribution, so the Mann-Whitney test was used to calculate the association between the numbers of errors of commission and omission in EMR drug profiles according to copayment status. Accordingly, the Spearman rank correlation test estimated the association between errors of commission in primary and secondary sections of EMR drug profiles.

The mean number of drugs per patient listed on the EMR drug profile was 9.4 for patients with a copayment and 12.1 for patients without a copayment, indicating that patients without a copayment had significantly more total drugs listed ( $P < .001$ ) (Table 1). Furthermore, patients without a copayment had significantly more current regimen drugs listed than patients with a copayment (11.8 vs 9.3,  $P < .001$ ) (Table 2). Although patients without a copayment had significantly more drugs listed and being taken than patients with a copayment, there was no significant difference in errors of commission or omission between the 2 groups. The mean numbers of errors of commission per drug profile were 0.6 for patients with a copayment and 0.5 for patients without a copayment ( $P = .96$ ) (Table 1). The mean numbers of errors of omission per drug profile were 0.5 for patients with a copayment and 0.2 for patients without a copayment ( $P = .19$ ). The Spearman rank correlation test demonstrated no significant difference in the mean numbers of errors of commission between primary and secondary sections of the EMR drug profiles, regardless of copayment status. In other words, there was no effect of medications entered in a patient’s EMR drug profile that were not being taken, regardless of whether the drugs were prescribed by the study hospital (Table 3). Table 4 lists the most frequent errors of commission and omission among the sample.

## DISCUSSION

### Results Comparison

The mean age of patients and the mean number of drugs listed on EMR drug profiles were similar between the Washington state hospital and the Iowa City VAMC; both hospitals demonstrated statistically higher ( $P < .01$ ) mean numbers of drugs listed on EMR drug profiles for patients without a copayment (12.1 and 13, respectively) than for patients with a copayment (9.4 and 9.6, respectively).

In the overall study samples, the mean number of current regimen drugs per patient at the Washington state hospital was less than that per patient at the Iowa City VAMC (10.2 vs 12.4). However, for both hospitals the mean number of current regimen drugs was significantly higher for patients without a copayment ( $P < .001$  for Washington state and  $P < .01$  for the Iowa City VAMC).

The percentages of EMR drug profiles with perfect accuracy were 56.0% at the Washington state hospital and 5.3% at the Iowa City VAMC. This large disparity may be because of the

■ **Table 4.** Most Frequent Errors of Commission and Omission by Drug Name

Errors of Commission (n = 118)	No. (%)	Errors of Omission (n = 68)	No. (%)
Aspirin	7 (5.9)	Multivitamin	6 (8.8)
Flunisolide	5 (4.2)	Aspirin	6 (8.8)
Ipratropium bromide	6 (5.1)	Vitamin E	5 (7.4)
Hydrochlorothiazide	4 (3.4)	Calcium	3 (4.4)
Lisinopril	3 (2.5)	Glucosaminoglycan	3 (4.4)
Albuterol	3 (2.5)	Drenatrophin	3 (4.4)
Felodipine	3 (2.5)	Tylenol	3 (4.4)
Simvastatin	3 (2.5)		
Multivitamin	3 (2.5)		

Washington state hospital's medication reconciliation program and its ability to add drugs to patients' EMR drug profiles, regardless of where the prescriptions originate. At the time of the 2004 study by Kaboli et al,<sup>5</sup> the Iowa City VAMC could only enter VHA-prescribed drugs into their patients' EMR drug profiles, and there was no process to verify drug regimens.

As in the study by Kaboli and colleagues,<sup>5</sup> our analysis revealed that the number of errors of commission in a patient's EMR drug profile is unassociated with copayment status. In other words, a patient's EMR drug profile is unlikely to show more errors of commission whether or not he or she shares the cost of drugs.

Kaboli and colleagues<sup>5</sup> found at the Iowa City VAMC that patients without a copayment had significantly fewer errors of omission in their EMR drug profiles, but we found at the Washington state hospital that errors of omission were unassociated with copayment status. This may be because patients with a copayment at the Iowa City VAMC sought cheaper alternatives, and after they obtained them, the Iowa City VAMC could not enter those drugs into their patients' EMRs.

We also found that errors of commission in the primary section of the drug profile were unassociated with errors of commission in the secondary section of the drug profile. In other words, no significant difference in errors of commission existed between drugs prescribed by the Washington state hospital and those obtained elsewhere.

Our method was different from that used by Kaboli and colleagues<sup>5</sup> for recording the number of drugs listed on the drug profile and the number of current regimen drugs per patient. Kaboli and colleagues used pharmacy benefit management data for patient drug profiles, while we used printed EMR drug profiles. As Monson and Bond<sup>16</sup> note, pharmacy data and patient EMRs show large variation, so direct comparison between results of the hospitals is impossible.

### Limitations

One limitation to our study is the sample size of 200. The Washington state hospital provides service to about 11,000 patients per year; therefore, it is unknown to what extent our findings are representative of their entire patient population.

Second, the results are subject to recall bias; it may be impractical to ask patients to recall their entire drug regimen. There was evidence that some patients do not remember every current regimen drug, with some simply taking the drugs that their spouse gives them each day. Kaboli and colleagues<sup>5</sup> asked patients to bring their medications to the interview, but this was not allowed at the Washington state hospital because of concern that patients would leave them behind.

Case-mix bias may be present in our study because of differences in severity of illness among 3 teams in the outpatient clinic, although patients are randomly assigned to a team before their first outpatient appointment. No systematic review was conducted to determine severity of illness, which may influence the number of drugs prescribed for a patient or the number a patient is taking.

### Future Research

Future research should acknowledge the different sources of drugs such as those prescribed at a patient's hospital and those obtained from other sources. Furthermore, a patient's decision to seek cheaper alternatives may be influenced not only by copayment status but by the amount of copayment. In addition, research should question the causes of an error of commission during a hospital staff interview (eg, did the patient finish a drug regimen or completely ignore it). It is also important to note that the cross-sectional design used in this study does not allow us to document how the medication reconciliation program specifically contributed to increased accuracy. Future research should use an intensive case study approach to obtain additional insight that will further add to

our knowledge about the role of medication reconciliation programs in improving the accuracy of drug profiles.

## CONCLUSIONS

An EMR that includes all of a patient's current regimen drugs, regardless of origin, is essential to increasing the accuracy of drug profiles. Furthermore, a medication reconciliation program must be consistently used to correct drug profiles before patient appointments. When providers are under incorrect assumptions about a patient's current drug regimen, subsequent prescriptions can lead to ADEs and ADRs, decreasing patient safety and adversely affecting health outcomes. Better integration of hospital-prescribed and community provider-prescribed medications in a functional EMR system, coupled with strong patient-provider communication regarding patient medications, may further improve the accuracy of drug profiles.

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