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Electronic Health Records and Adverse Drug Events after Patient Transfer

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Abstract

Background—Our objective was to examine the frequencies of medication error and adverse drug events (ADEs) at the time of patient transfer in a system with an electronic health record (EHR) as compared to a system without an EHR. We hypothesized that the frequencies of these events would be lower in the EHR system because of better information exchange across sites of care.

Methods—469 patients transferred between 7 nursing homes and 3 hospitals in New York and Connecticut between 1999-2005 were followed retrospectively. 2 groups of patients were compared: U.S. Veterans Affairs (VA) patients, with an EHR, and non-VA patients, without an EHR, on the following measures: 1) Medication prescribing discrepancies at nursing home/hospital transfer; 2) High-risk medication discrepancies; and 3) ADEs caused by medication discrepancies according to structured medical record review by pairs of physician and pharmacist raters.

Results—The overall incidence of ADE caused by medication discrepancies was 0.20 per hospitalization episode. After controlling for demographic and clinical covariates, there were no significant differences between VA and non-VA groups in medication discrepancies (mean difference 0.02; 95%CI −0.81 to 0.85), high-risk medication discrepancies (−0.18; 95%CI −0.22 to 0.58), or occurrence of an ADE caused by a medication discrepancy (odds ratio 0.96; 95%CI 0.18 to 5.01).

Conclusions—There was no difference, with and without an EHR, in the occurrence of medication discrepancies or ADEs caused by medication discrepancies at the time of transfer between sites of care. Reducing such problems may require specialized computer tools to facilitate medication review.

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Keywords

Medical records systems-computerized; medication error; medication systems; nursing homes; hospitals

INTRODUCTION

Patient transfers or handoffs between sites of care are common in health care systems and are associated with communication lapses that cause adverse events. Discrepancies in medication prescribing are common lapses that occur during transfer and such discrepancies cause adverse drug events (ADEs).[1-3] Standard medication review and reconciliation procedures have been tested to reduce such ADEs in several countries.[4,5] In the U.S. the Joint Commission established medication reconciliation during patient handoffs as a safety standard in 2006.[6]

An electronic health record (EHR) portable or accessible across sites of care should improve communication between sites of care and reduce errors by enabling providers to see more complete prescribing information, read past and current notes, and prescribe medication electronically.[7] According to the U.S. Institute of Medicine exchange of patient care data and communication among care settings are basic and required functions of an EHR.[8] As a prominent example, the U.S. Department of Veterans Affairs (VA) has an EHR that enables VA providers to view health care encounter notes, summaries, orders, pharmacy, radiology, and lab results from any VA setting. Communication forms to exchange health information between sites of care are unnecessary. Yet, whether an EHR like the VA's changes the likelihood of medication discrepancies or ADEs from medication discrepancies at the time of patient handoffs is unknown.

The objective of this study was to examine the frequencies of medication discrepancies and ADEs from medication discrepancies at the time of patient handoff within the VA system as compared to outside the VA system, where paper forms, sometimes handwritten, are used to communicate health information. We hypothesized that the frequencies of these events would be lower in the VA system owing to its advanced EHR, as compared to our non-VA study sites where an EHR was not available for information exchange.

METHODS

Setting and Participants

The study was an observational cohort study, in which 2 groups of patients were compared: VA, with an EHR, and non-VA, without an EHR, in New York and Connecticut between 1999-2005. The VA group consisted of patients from four VA nursing homes who were admitted to two VA hospitals that were the primary referral hospitals for the nursing homes. The non-VA group consisted of patients from three non-VA nursing homes who were admitted to one non-VA hospital that was the primary referral hospital for the nursing homes. All VA and non-VA study hospitals were academic centers located in urban areas, and all study nursing homes were located in urban or suburban areas.

Eligible patients were individuals transferred from nursing home to hospital and admitted, and who remained in the hospital at least 24 hours. Individuals were included whether or not they survived to hospital discharge and whether or not they returned to the nursing home from which they originated. Institutional review boards of Mount Sinai School of Medicine, James J. Peters VA Medical Center, VA Connecticut Healthcare System, and Jewish Home Lifecare approved a waiver of informed consent, since data were collected by retrospective medical record review.

Measurements

Medication Discrepancies—Research personnel reviewed nursing home and hospital records to identify medication prescribing discrepancies at transitions between sites of care, which were hospital-to-nursing home transfer and nursing home-to-hospital transfer if the patient survived to discharge and returned to the same nursing home. Records reviewed included medication orders, transfer documents, medication administration information, and discharge instructions. A discontinuation, dose change, frequency change, route change or substitution for a medication with the same indication at the time of transition was labeled a prescribing discrepancy. We included substitutions caused by nursing home and hospital drug formulary differences, but excluded substitutions between generic and brand-name versions of the same drug. Discrepancies in 14 drug classes were classified as high risk (angiotensin blockers, antiarrhythmic agents, anticoagulants, antiepileptic agents, antiprostate agents, antipsychotics, calcium blockers, insulin, metronidazole, nitrates, non-opioid analgesics, opioid analgesics, sedative/hypnotics, and thyroid replacements). These were compiled from the Institute for Healthcare Improvement's High Alert medication drug classes,[9] high-risk drug classes for nursing home patients[10,11] and other classes with higher likelihood of causing a discrepancy-related ADE.[12] Topical agents, vitamins, minerals and as-needed medications not in a high risk drug class were excluded. Laxatives were excluded because of ascertainment differences between VA and non-VA groups.

Adverse Drug Events Caused by Medication Discrepancies—A subsample of nursing home and hospital records was reviewed for up to two months after each transition between the care sites for ADEs caused by medication discrepancies. The subsample was randomly selected except patients from nursing homes with fewer hospitalizations were oversampled. Two trained clinician investigators (2 physicians or one physician and one pharmacist) reviewed records for medical incidents that were defined in advance, including: new or worse bleeding, congestive heart failure, delirium, diarrhea, dyspnea, fall, decrease in alertness, incontinence, pain, rash, urinary retention, vomiting, blood pressure abnormalities (new systolic blood pressure >185 or <95, diastolic blood pressure >105), fever (temperature >100.5F), and abnormal tests of kidney function (creatinine increase >.5), liver function (doubling of aspartate aminotransferase or alanine aminotransferase), or over-anticoagulation (international normalized ratio >4.0). Other laboratory abnormalities (e.g., hypo- or hyperglycemia, hyperkalemia) were recorded if symptomatic or if they caused a cardiac arrhythmia.

Each rater recorded whether a medical incident could have been caused by a prescribing discrepancy at the time of transfer between care sites using structured implicit review. Implicit review criteria included: 1) whether the incident was a physiologically possible consequence of the medication prescribing discrepancy, 2) whether there was a note in the medical record that suggested that a medication discrepancy caused the incident, 3) the time interval between incident and discrepancy, 4) whether the incident could have been caused by something other than a medication discrepancy, and 5) whether the patient's condition improved after correction of the medication discrepancy.

The 2 raters discussed each event and provided a consensus rating using a six-point Likert scale, with 1 indicating "little or no" certainty and 6 indicating "almost total" certainty[13] that a drug discrepancy caused an ADE. For this study, ADEs were defined as events for which the consensus rating was ≥ 4. Raters then decided whether an ADE was the result of a prescribing error according to whether there was an appropriate clinical rationale for the prescribing discrepancy or the discrepancy deviated from prescribing norms, as determined by discussion consensus. Finally, raters scored ADE severity, using modified National Coordinating Council

for Medication Error Reporting and Prevention (NCCMERP) categories, indicating whether the ADE caused symptoms, a prolonged or additional hospital stay, permanent harm, or death.

Patient Characteristics—Information was collected on patient age, gender, race, and number of prescribed medications from the nursing home record. A score for burden of chronic disease, adapted from Charlson et al.[14], was calculated from chronic medical problems listed in the nursing home record. Information on hospitalization episode diagnoses, time of admission (8 a.m.-6 p.m. Monday-Friday vs. off-hours), and hospital length of stay were obtained from the hospital record. An illness severity score, modified from the Acute Physiology and Chronic Health Evaluation (APACHE) score,[15] was calculated from initial laboratory data and vital signs in the hospital record.

Analysis

Because a single patient could contribute more than one hospitalization episode to the study, the unit of analysis was hospitalization episode. Baseline characteristics of VA and non-VA patients and characteristics of their hospitalization episodes were compared, using the t-test for continuous variables and chi-square test for categorical variables. The main study outcomes were medication discrepancies, high risk medication discrepancies, and ADEs caused by medication discrepancies during transfer to or from the hospital. We calculated VA/non-VA group differences in the mean number of medication discrepancies and mean number of high risk medication discrepancies, and the VA/non-VA group odds that an ADE caused by a medication discrepancy occurred during transfer, each with 95% confidence intervals (95% CI). To adjust for differences between VA and non-VA patients, regression models were fitted in which VA or non-VA group was the key independent variable; gender, age, pre-hospitalization number of medications, Charlson comorbidity score, APACHE score, off-hours admission, admission diagnoses, and duration of follow-up were covariates; and medication discrepancies, high-risk discrepancies, and ADE were the dependent variables. We used generalized estimating equations (GEE) to account for clustering of observations within patients and facilities. 95% confidence intervals, p-values, odds ratios, and the c statistic were calculated using standard formulae. All analyses were performed using SAS software version 9.1 (Cary, NC).

RESULTS

The study sample consisted of 226 VA nursing home patients hospitalized 331 times and 243 non-VA nursing home patients hospitalized 387 times. Characteristics of patients and their hospital stays are shown in Table 1. VA patients were younger, more likely to be male, and more likely to be admitted during off-hours. The most common reasons for hospitalization in both groups were pneumonia (in 18% of cases), urinary tract infection (17%), dehydration (11%), and exacerbations of congestive heart failure (8.5%) and chronic obstructive pulmonary disease (4.0%). There was no difference in prehospitalization number of medications prescribed. Median hospital length of stay was longer by 1 day in the VA group than in the non-VA group.

The total number of prescribing discrepancies observed in both study groups was 1854 at the time of nursing home-to-hospital transfer and 1059 at the time of hospital-to-nursing home transfer, for a mean of 2.58 (s.d. 2.17) and 1.61 (s.d. 1.85) discrepancies per transfer, respectively. Sixty-four percent of discrepancies were drug discontinuations, 19% were dosage or frequency changes, 12% were substitutions for a medication with the same indication, and 5% were other types. In the subsample of records reviewed for ADEs, the total number of ADEs caused by discrepancies at the time of nursing home-to-hospital or hospital-to-nursing home transfer was 61, for an ADE incidence of 0.20 (95% CI .16 to .25) per hospitalization

episode. Fifty-two percent of prescribing discrepancies that caused ADEs were considered to be appropriate prescribing changes and 48% were considered to be prescribing errors. Errors included wrong omissions (46%), errors in drug frequency (46%), and errors in drug dosage (8%). Forty-six percent of ADEs were asymptomatic, 52% were associated with symptoms, and 3% caused a prolonged or an additional hospital stay. No ADE resulted in permanent disability or death.

In unadjusted comparisons, the VA group, as compared to the non-VA group, had a similar number of transfer-related medication discrepancies (mean 2.62 vs. 2.55; difference 0.07 (95% CI −0.26 to 0.42); p=.66) and a higher number of high-risk discrepancies (mean 0.96 vs. 0.75; difference 0.21 (95%CI 0.05 to 0.38); p=.01) per hospitalization episode; and had a similar percentage of hospitalization episodes in which an ADE caused by a medication discrepancy occurred (18.1% vs. 21.5%; OR 0.83 (95%CI 0.44 to 1.59 p=.57) (Table 2). In adjusted comparisons, after controlling for patient demographic and clinical covariates, there were no significant differences between VA and non-VA groups in any outcome (medication discrepancies, high-risk medication discrepancies, or ADEs caused by medication discrepancies) (Table 2). The c statistic for our ADE outcome model was 0.682, which indicates fair discrimination. In addition, there were no significant differences between VA and non-VA groups in ADE severity or in ADEs caused by prescribing errors (Table 3).

Examples of ADEs caused by 3 common types of medication discrepancies are shown in Table 3. The first type of discrepancy was a purposeful prescribing change with an appropriate clinical rationale that ultimately caused harm; e.g., a case of an omission of transdermal nitroglycerin in a VA patient with low blood pressure at the time of hospital admission that caused harm when the patient's angina relapsed. The second discrepancy type was a purposeful prescribing change that lacked an appropriate clinical rationale; e.g., a case of omission of transdermal fentanyl in a VA patient with chronic pain that caused pain relapse. The third discrepancy type was an inadvertent transcribing error associated with a provider incorrectly re-entering a medication order at the time of transfer; e.g., a case of dosage increase in phenytoin in a VA patient that caused a supratherapeutic phenytoin level. As shown, there were ADEs caused by each of these types of discrepancies in the VA group that were not averted by the VA's EHR.

DISCUSSION

Substantial worldwide resources are being directed toward building capacity for electronic health information exchange. These efforts complement longstanding electronic health information exchange capacity within the U.S. VA system. In the U.S. the existence of the VA system with its mature EHR alongside non-VA settings without an EHR, afford an opportunity to test whether the EHR is associated with better prescribing at the time of inter-facility patient transfer. Our hypothesis was refuted by the finding that hospitalized nursing home residents in the VA setting had no difference in the occurrence of medication discrepancies, high risk medication discrepancies, or ADEs caused by medication discrepancies at the time of transfer as compared to those in the non-VA setting.

No previous studies have isolated the effect of an EHR on prescribing outcomes at the time of transfer between sites of care. Our findings are consistent with a previous study that demonstrated that ADEs from errors in medication ordering are common even in a highly computerized system.[16] Barriers to effective medication reconciliation and review at the time of transfer in a computerized setting include: computerized medication information that is incomplete or unclear, a reliance on the computer by providers that leads to less thorough patient interviews and less careful medication reviews, poor computer interface design, and competing provider tasks such as high volume or very ill patients. At the time of this study, the VA EHR provided excellent access to many types of information but did not provide tools

that facilitated medication review or reconciliation. Yet, our study and others[17-20] suggest that reducing medication discrepancies at the time of inter-site transfer has the potential to prevent ADEs. Procedures that might improve this process in computerized and non-computerized settings include: dedicating staff to complete standardized medication reconciliation and review, integrating the task into other provider tasks such as documentation or ordering, and alerting providers in real time when a prescribing discrepancy is detected that has a higher likelihood of causing an ADE.

A limitation of this study is the small overall number of ADEs. However, the confidence intervals for the differences in medication discrepancies and high-risk medication discrepancies were small, suggesting that the null finding is robust. In addition, the small fraction of severe ADEs in this study is concordant with reviews that indicate that serious ADEs make up only a small fraction of total ADEs.[21,22] It is possible that our no difference finding could have occurred because of a lower than expected number of medication discrepancies in the non-VA group, which had better information exchange than that observed in older studies.[23] Our null finding could also have been influenced by ascertainment bias, whereby the VA's comprehensive and readable EHR increased the likelihood of finding ADEs in the narrative record. However, this should not have affected our ascertainment of medication discrepancies or of high risk medication discrepancies, which did not involve review of the narrative record. It should be noted that data from this study preceded the U.S. Joint Commission 2006 medication reconciliation standard, when most facilities implemented a procedure for medication reconciliation. Nevertheless, to date provider adherence rates to medication reconciliation protocols are low and Joint Commission citations for problems with compliance are common,[24] even in the VA system. Finally, our no difference finding could have been specific to the small sample of facilities studied and not representative.

In conclusion, implementation of an EHR, and ensuring interoperability among EHRs, would not alone be expected alone to resolve the problem of ADEs from medication discrepancies at the time of inter-site transfer. Reducing such problems may require specialized computer tools to facilitate medication review and reconciliation, and attention to EHR usability and implementation to reduce provider and system barriers to accurate medication prescribing.

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Table 1

Characteristics of hospitalized nursing home patients and their hospitalizations, stratified by VA / non-VA group.

	VA	Non-VA
Patients (n)	226	243
Age (mean years (s.d.))	70.0 (13.0)	82.8 (10.6)*
Male (%)	97.3%	25.4%*
Hospitalizations (N)	331	387
Hospitalizations / Patient (N / n)	1.5	1.6
Pre-Hospitalization Medications (mean number (s.d.))	6.0 (3.1)	6.2 (2.9)
Hospital admission off-hours§ (%)	63.4%	52.3%†
Hospital length of stay (median days (range))	7 (1-296)	6 (1-98)‡

*P < .001 for comparison with VA group

†P < .01 for comparison with VA group

‡P ≤ .05 for comparison with VA group

§Not during regular business hours (8 a.m.-6 p.m. Monday-Friday)

Table 2

Medication discrepancies and ADEs caused by medication discrepancies in hospitalized nursing home patients, stratified by VA / non-VA group.

	VA	Non-VA	Unadjusted difference	Adjusted difference*
Medication discrepancies† (mean (s.d.))	2.62 (2.16)	2.55 (2.18)	Diff = 0.07 (−0.26 to 0.42)	Diff = 0.02 (−0.81 to 0.85)
High-risk medication discrepancies† (mean (s.d.))	0.96 (1.07)	0.75 (0.92)	Diff = 0.21 (0.05 to 0.38) §	Diff = −0.18 (−0.22 to 0.58)
ADE caused by a medication discrepancy‡ (% of hospitalization episodes)	18.1%	21.5%	OR = 0.83 (0.44 to 1.59)	OR = 0.96 (0.18 to 5.01)
(Subsample n=127 VA; n=177 non-VA)				

*All models adjusted for gender, age, pre-hospitalization number of medications, Charlson comorbidity score, APACHE score, off-hours admission, admission diagnoses, and duration of follow-up.

†At the time of hospital admission

‡At the time of hospital admission or discharge

§P = .01 for VA / non-VA group comparison

Table 3

Complications of ADEs caused by medication discrepancies, stratified by VA / non-VA group.

ADE caused:	VA	Non-VA*	Example: Discrepancy (ADE)
No symptoms (%)	42	48	VA: Phenytoin dosage increase (supratherapeutic phenytoin level) Non-VA: Clonidine omitted (hypertension)
Symptoms only (%)	54	50	VA: Fentanyl transdermal omitted (pain) Non-VA: Carbamazepine dosage decrease (seizure and lethargy)
Prolonged or additional hospital stay (%)	4	2	VA: Nitroglycerin transdermal omitted (cardiac ischemia, hospital readmission) Non-VA: Colchicine omitted (gout flare, prolonged hospital stay)
Permanent harm or death (%)	0	0	None

* $P \geq .05$ for all comparisons with VA group, by chi-square test.