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Drug prescription behavior and decision support systems

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ABSTRACT

Adverse drug events plague the outcomes of health care services. In this research, we propose a clinical learning model that incorporates the use of a decision support system (DSS) in drug prescriptions to improve physicians' decisions about the initial drug selection and administration. The model allows for both the analytical investigation of the effects of different DSS features on clinical learning and the estimation of the physician learning behavior given a panel data set. The analytical results suggest that using a DSS to improve physicians' prescription decisions would positively influence their clinical learning. Conversely, without improvements in successful drug selection, the use of a DSS would negatively affect clinical learning. The empirical results provide further evidence on the factors that drive physicians' responses to information sources and the extent to which they rely on clinical experience in prescribing drugs.

1. Introduction

Researchers estimate that adverse drug events (ADEs) cause between 700,000 and 1.5 million injuries annually [16,47,48,73]. A prominent study suggests that 28 percent of the ADEs, most of which are due to prescription errors [41,46,49], are preventable [6]. Mirco et al. [57] find that the most common prescription errors are deficiencies related to choosing the right drug, dosage, frequency, route of administration (i.e., pills, gels, and liquids), drug interactions, and length of therapy.

The sheer number of prescription errors has its roots in the challenges that physicians face in keeping abreast of developments in pharmacology. As powerful new drugs and clinical information become available, the need for accurate prescription decisions grows proportionately. Thus, deficiencies in keeping up with new developments in pharmacology unavoidably lead to suboptimal prescription decisions, even though the choice and administration of drugs make up some of the most important clinical decisions in medical practice [69].

Continuous physician learning is arguably the most effective solution to reducing prescription errors. Physician learning involves effectively integrating the clinical experiences with the most recently acquired information and then modifying the prescription behavior accordingly. Physicians regularly update their beliefs and thus learn about the efficacy of drugs from their own clinical experiences [23]. Improving prescription decisions through continuous learning would not only minimize preventable ADEs and provide better treatments for the patients, but also improve patient satisfaction [24,28], reduce insurance risks, and lead to superior quality and audit ratings for the physicians [51].

When integrated with clinical, practice guidelines and workflows, decision support systems (DSSs) and computerized physician order entry (CPOE) can help physicians with their clinical learning and thus enhance their prescription decisions. CPOE refers to computerized systems that automate the medication ordering process. Basic CPOE features include verification of typed orders in a standard and complete format, and CPOE systems typically have or interface with DSSs of varying sophistication, although some DSSs are implemented without a CPOE [41]. In general, CPOE and DSSs support two types of decisions: drug selection and drug administration. Drug selection refers to the initial decision of matching a patient with an appropriate drug from a set of alternatives. Computerized decision support on drug selection is provided through drug recommendations, drug–allergy checks, drug–laboratory value checks, and drug–drug interaction checks. Drug administration refers to how the selected drug should be administered in terms of dosage, frequency, route, and length of therapy, and such decisions are supported with appropriate recommendations by the software. The drug selection feature of CPOE has been shown to reduce the rate of non-intercepted, serious prescription errors by more than half [7,8]. The use of DSSs has also been shown to reduce the errors associated with drug administration (i.e., decisions regarding medication dosage, frequency, and route). Table 1 summarizes the literature on the effect of DSS use on prescription decisions and outcomes.

Because DSSs do not replace physician judgment,[1] the sustainable positive results can be achieved only through improved physician learning supported with DSSs. Bochicchio et al. [10] also argue that the main

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[1] For example, Burke and Pestotnik [15] find that physicians prescribe the computer-suggested antibiotics only approximately 46 percent of the time.

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Table 1
Studies on the impact of CPOE and DSS usage on prescription errors.

Study	Type of decision support	Result
Bochicchio et al. [10]	Drug	21% improvement in antibiotic decision accuracy (P = 0.005).
Hunt et al. [37]	Dosing	9 of 15 studies showed improvement in drug dosing.
Kirk et al. [45]	Dosing	Significantly fewer dosing errors for computer-assisted prescriptions than their traditional counterparts (P<0.001)
Bates et al. [7]	Drug and dosing	55% reduction in non-intercepted serious medical errors (P = 0.37) and 17% reduction in preventable ADEs (P = 0.37)
Bates et al. [8]	Drug, dosing, and frequency	81% reduction in prescription errors (P = 0.01) and 86% reduction in non-intercepted serious prescription errors (P = 0.01)
Ammenwerth et al. [3]	Drug, dosing, and frequency	4 of 6 studies showed a significant relative risk reduction in ADEs. 23 of 25 studies showed a significant relative risk reduction in prescription errors.
Teich et al. [70]	Drug, dosing, and frequency	Statistically significant improvements in five types of drug selection and administration decisions
Evans et al. [30]	Drug, dosing, frequency, and route	70% reduction in ADEs caused by anti-infectives (P = 0.02)
Burke and Pestotnik [15]	Drug, dosing, frequency, and route	ADE rate dropped from 1.22% to 0.04%.

benefit of computerized decision support is simply improved pharmacological knowledge. Physicians assume full responsibility of their prescribing decisions with or without using a DSS, and therefore the most successful DSSs are those that best facilitate physician learning.

Our objective in this paper is to understand the interaction between physician learning and the use of a DSS and the corresponding impact on prescription decisions. We also aim to understand which type of decision support is more critical for physician learning. To this end, we develop a model of physician prescription behavior supported by two types of DSS features. One category of DSS features supports the decisions regarding when to prescribe a focal drug (drug selection), and the other category supports the drug administration decisions for the focal drug. Using the DSS features can potentially reduce the variances and uncertainties behind drug selection and administration decisions and influence physicians' learning, with the objective that prescription behaviors are in line with the clinical guidelines established for the focal drug. The proposed framework provides both an analytical model to investigate the effects of these two DSS capabilities and an empirical model to estimate the physician prescription behavior given a panel data set (for other similar empirical models, see [1,23,46]). The model accounts for the following two factors: (1) physicians may be subject to different patient profiles and experiences, and (2) they may arrive at different clinical conclusions, even after observing the same evidence, because of their prior clinical experiences [46].

Using the proposed model, we ask the following research questions: How are the two types of DSS features related to physicians' clinical learning about a focal drug? What are the salient physician characteristics that affect clinical learning? What are some of the important physician-level factors that facilitate the adoption of DSSs? We use a hierarchical Bayesian estimation technique that captures the individual, physician-level uncertainties and learning behavior. Thus, the proposed model can be used to analyze, compare, and contrast different physician responses to the use of computerized decision support in the prescription process. Previous research in information systems has shown the importance of combining individual-level learning behavior and user environment [38]. A contribution of this study is that it combines physician learning and the use of information technology in modeling physician behavior. The analytic modeling approach combined with the empirical analysis of clinical learning behavior provides a powerful framework for capturing the impact of DSS on physician learning.

The analytical results emphasize the importance of computerized support for drug selection decisions and highlight both the benefits and the risks associated with designing and implementing DSSs. When DSSs lead to superior drug selection decisions, patient-level observations are better integrated into the prescription behavior, which improves physician learning. An implication of this result is that proper design and use of DSS may help in enforcing compliance with treatment protocols and reducing prescription errors. Thus, the model provides an explanation on when and how the use of a DSS would allow us to observe physician decisions similar to those of an expert panel [67]. We also find that, without improvements in the accuracy of drug selection decisions, the use of a DSS negatively influences the physicians' clinical learning because they attribute less importance to the information they gather from patients than to their established expectations of the drug. Consequently, improper design and implementation may lead to negative outcomes [22,49].

The empirical results provide further evidence on the role of the information acquired through clinical experience. We find that physicians differ substantially with regard to their responses toward the information sources and clinical experiences. Physician specialty and location have significant effects on the overall physician responses to new information about a focal drug. General practice physicians (i.e., generalists) and physicians located in high-income areas rely more on their clinical experiences than specialists and physicians located in low-income areas, respectively. Accordingly, our analysis suggests that computerized decision support for drug selection benefits specialists and physicians located in low-income areas relatively more. These results provide further evidence on the importance of specialty and location on the success of DSS use.

We organize the rest of the paper as follows: We first present an analytical model that captures the physician prescription and learning behavior in Section 2. Then, we describe our data and empirical methods in Section 3. The empirical results on salient physician characteristics and how they are related to DSS usage are then presented in Section 4. The paper concludes with a summary and discussion in Section 5.

2. Model

We begin with a basic model that formulates physicians' prescription of a focal drug in the absence of DSS and clinical learning. We extend the model first with two DSS features and then with a mechanism for clinical learning about the focal drug. Finally, we present the analytical results on how the two DSS features facilitate physician learning.

2.1. Basic model

Consider, for example, patients who suffer from existing conditions that require ongoing treatments. Bipolar disorders or cardiovascular diseases are examples of such conditions. Physicians consider prescribing a focal drug in treating their patients given the existing condition. Physicians also prescribe the focal drug according to their preferences, past habits, and external information sources about the drug [69]. Physicians differ depending on the profile of their patients, their prescription habits, and their responses to the external information they receive about the

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