Introduction

The annual cost of morbidity and mortality due to medication errors in the United States has been estimated at $76.6 billion. Information technology implemented systematically has the potential to significantly reduce medication errors that result in adverse drug events (ADEs). A computer simulation model was developed that can be used to evaluate the effectiveness of information technology applications designed to detect and prevent medication errors that result in adverse drug effects.

A computer simulation model was constructed representing the medication delivery system in a hospital. STELLA, a continuous simulation software package, was used to construct the model. Parameters of the model were estimated from a study of prescription errors on two hospital medical/surgical units and used in the baseline simulation. Five prevention strategies were simulated based on information obtained from the literature.

The model simulates the four stages of the medication delivery system: prescribing, transcribing, dispensing, and administering drugs. We simulated interventions that have been demonstrated in prior studies to decrease error rates. The results suggest that an integrated medication delivery system can save up to 1226 days of excess hospitalization and $1.4 million in associated costs annually in a large hospital. The results of the analyses regarding the effects of the interventions on the additional hospital costs associated with ADEs are somewhat sensitive to the distribution of errors in the hospital, more sensitive to the costs of an ADE, and most sensitive to the proportion of medication errors resulting in ADEs.

The results suggest that clinical information systems are potentially a cost-effective means of preventing ADEs in hospitals and demonstrate the importance of viewing medication errors from a systems perspective. Prevention efforts that focus on a single stage of the process had limited impact
on the overall error rate. This study suggests that system-wide changes to the medication delivery system are required to drastically reduce medication errors that may result in ADEs in a hospital setting.

Based on the Harvard Medical Practice study of 51 hospitals in the state of New York [1,2] and a sample of hospitals in Utah and Colorado [3], the Institute of Medicine (IOM) estimated that between 44,000 and 98,000 deaths occur in the United States each year as a result of medical errors [4]. Although the exact number of deaths due to medical errors is a subject of debate [5,6], meta-analyses of 39 prospective studies performed in the United States between 1966 and 1996 indicated that even when drugs are properly prescribed and administered, adverse drug reactions may rank between the fourth and seventh leading cause of deaths in the United States, exceeding car accidents, suicide, homicide, or AIDS [7].

The Harvard Medical Practice study found that the top cause of adverse events in hospitalized patients was drug complications, which accounted for 19 percent of the adverse events [2]. An ADE is defined as “an injury resulting from medical intervention related to a drug” [8]. A recent study found that the rate of ADEs was 6.5 per 100 hospital admissions. Errors were detected at every stage of the process: ordering (56%), transcription (6%), dispensing (4%), and administration (34%) [8,9]. The severity of the adverse drug events was 1% fatal, 12% life-threatening, 30% serious, and 57% significant. Other studies of hospitals in Utah and Colorado [3], pediatric inpatients [10], and hospital intensive care units [11], have also found high rates of ADEs.

Deaths due to medication errors in the United States may be increasing. One study found a 2.57-fold increase in deaths attributed to medication errors between 1983 and 1993 [12]. One factor that may account for this increase is the shift from inpatient to outpatient care [13]. During this decade, inpatient days fell by 21 percent while outpatient visits increased by 75%.

Studies of hospitalized patients indicate that serious adverse drug events increase the length of hospital stay and costs. One study estimated the additional length of stay associated with an ADE was 2.2 days; the increase in cost associated with an ADE was $3,244 [14]. Based on these costs and incidence rates of ADEs, it was estimated that the annual costs attributed to all ADEs for a 700-bed hospital were $5.6 million. A second study conducted at LDS Hospital in Salt Lake City estimated that the extra length of hospital stay attributable to an ADE was 1.74 days, whereas the extra cost of hospitalization was estimated to be $2,013 per patient [15]. During one year of the study a total of 567 ADEs were detected. The direct hospital costs associated with these ADEs were $1.1 million. Over the four years of the study excess hospital costs due to ADEs were estimated at $4.5 million. The total annual cost of morbidity and mortality due to drug-related errors in the United States has been estimated at $76.6 billion [16].