Case Report ■

Computerized Reminders Reduce the Use of Medications during Shortages

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Abstract Medication shortages pose serious problems in health care. This study examines the impact of a computer-based reminder in addressing a national methylprednisolone shortage. An alert was designed and implemented in a computerized order entry platform at a children's hospital. The alert informed physicians of the shortage and provided an alternative prescribing pathway. Data regarding the number and type of parenteral corticosteroid prescriptions were collected for a one-month period before and after the alert was implemented. The alert resulted in a 55% relative reduction in methylprednisolone use and an average reduction of more than three orders each day. Dexamethasone and hydrocortisone, the recommended alternative medications, increased in use by 12% and 49%, respectively. The alert resulted in a $36,552 annualized cost reduction to the institution. Similar alert applications have great potential for effectively altering physician prescribing behavior.

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In 2001, Abbott Pharmaceuticals suspended production of methylprednisolone, a medication commonly prescribed for inpatients with asthma.[1] Since that time, methylprednisolone has been on national shortage,[2] with hospitals struggling to maintain their limited supplies. The challenge presented to health care providers by this problem is not new because medication shortages have been a concern in the United States for many years. However, the frequency and severity of national drug shortages have been increasing in recent years due primarily to manufacturing problems and production discontinuation.[2,3] Traditional methods of responding to national drug shortages seem inadequate to deal with the regularity and intensity of the shortages.[3] Physicians often either do not have access to up-to-date information on drug shortages or do not have the time to read the significant number of e-mails and newsletters typically used by health care institutions. In July 2002, the American Medical Association and the American Society of Health-System Pharmacists noted that the "Food and Drug Administration, manufacturers, group purchasing organizations, distributors, hospitals, physicians, pharmacists, and other stakeholders should establish better communications regarding drug product shortages, including notifications about imminent shortages and future availability."[3]

An effective solution to this problem would include communication with clinicians during the prescribing process without workflow interruption. Computer-based clinical decision support systems (CDSSs) may be an ideal approach to optimizing this communication. Recent studies have demonstrated the positive effects that CDSS can have on the quality of health care delivered. CDSS have been shown to reduce the risk of potential adverse drug events (ADEs) due to errors in prescribing, transcribing, dispensing, and administration of medications.[4–8] By reminding physicians of accepted clinical guidelines, CDSSs can significantly reduce the risk of inappropriate prescriptions in surgical patients.[9] Computer-generated reminders at the time of order entry can alter physician prescribing behavior, significantly reducing the number of redundant laboratory tests ordered and lowering hospital costs.[10,11] We hypothesized that use of a CDSS that educates clinicians regarding the national shortage of methylprednisolone during the prescribing process would encourage physicians to use alternative medications, resulting in a significantly reduced number of orders for methylprednisolone.

Methods

This study took place at Cincinnati Children's Hospital Medical Center (CCHMC), a 324-bed tertiary care pediatric institution that serves an area with more than 550,000 children. Between April and December 2002, CCHMC implemented an Integrating Clinical Information System (ICIS), which is browser-based and includes computerized order entry, clinical documentation, an electronic medication administration record, advanced clinical decision support,

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and a data storage repository. On average, more than 24,000 orders are entered each week, with 90% of orders entered directly into the computer by physicians or advanced practice nurses, with the remaining 10% entered by nurses after receiving a verbal order. The ICIS utilizes medication allergy, duplicate medication, medication interaction, and medication dose range checking as standard support tools. In addition, the platform allows the development of system edits and rules for support of clinicians in their prescribing and documentation roles. For this study, an additional medication shortage alert support tool was developed within the ICIS to address the methylprednisolone national shortage (see Example Solution with Results section). By selecting one of two recommended therapeutically equivalent medications, the prescriber was diverted from ordering the medication in short supply.

The study was sequential in design, consisting of a comparison of the numbers of prescriptions entered for methylprednisolone over a time period prior to the introduction of the alert and after introduction of the alert. The first study period (control period) began April 1, 2003, and ended April 30, 2003. The alert became operational on May 23, 2003, and after allowing a one-month latent period to permit physicians to become familiar with the alert, the second study period (post-alert period) began July 1, 2003, and concluded July 31, 2003. To determine the effectiveness of the alert, the data from each study period were analyzed both as raw numbers of methylprednisolone orders and as rates in relation to the total number of parenteral corticosteroids ordered. The rates were compared by χ^2, with $p \leq 0.05$ considered significant. The numbers of grams utilized and costs per gram for each of the three medications were compared in the two study periods and an annualized cost analysis was performed.

Example Solution with Results

The methylprednisolone shortage alert was designed such that each time a prescription for this medication was entered into ICIS, a message would appear on the computer screen alerting the clinician that there is a critical shortage of the medication, along with a recommendation for one of two therapeutically equivalent medications (dexamethasone or hydrocortisone), including dose conversions (Figure 1).

A total of 2,124 parenteral corticosteroid orders were analyzed. There were 970 corticosteroid orders during the control period and 1,154 orders during the post-alert period. A total of 321 methylprednisolone orders were placed during the entire study period, 209 (65%) during the control period and 112 (35%) during the post-alert period. This decrease of 97 orders is equivalent to a 55% relative reduction in the number of methylprednisolone orders. There was a significant decrease in methylprednisolone prescribing along with significant increases in dexamethasone and hydrocortisone prescribing (Table 1). There was a significant increase in the number of orders for the alternative medications dexamethasone (12% relative increase) and hydrocortisone (49% relative increase) in the post-alert period.

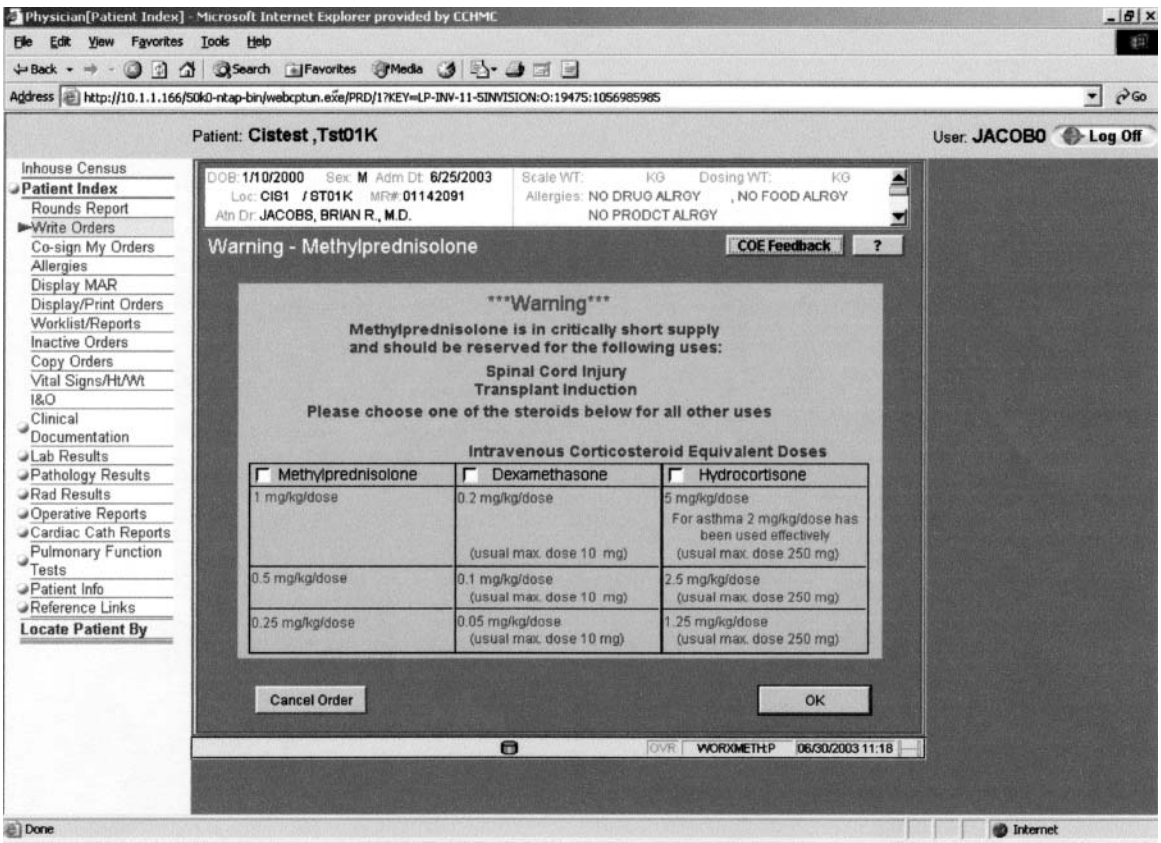

Figure 1. Computer screen reprint from the Integrating Clinical Information System (ICIS) resulting from physician selection of methylprednisolone. This alert suggests alternative medication choices to the clinician in place of methylprednisolone.

Table 1 ■ Effect of Methylprednisolone Prescribing Alert on Corticosteroid Orders

	Control Period	Post-alert Period	p-value
Total parenteral steroid orders	970	1,154	NS
Methylprednisolone orders (%)	209 (21.5%)	112 (9.7%)	< 0.0001
Dexamethasone orders (%)	702 (72.4%)	937 (81.2%)	< 0.0001
Hydrocortisone orders (%)	59 (6.1%)	105 (9.1%)	< 0.0001

NS = not significant.

Discussion

The results of this study suggest that CDSSs are an effective tool in conserving medications during times of national shortage by rapidly changing prescribing practices. Optimizing clinician response to national drug shortages has traditionally been difficult as constant communication and reminders are needed to restrain physicians from long-standing prescribing practices. The ICIS methylprednisolone alert provided a fast and reliable clinician reminder and was effective in reducing parenteral methylprednisolone orders nearly in half by an average of more than three orders each day.

In conserving medications in short supply in favor of more readily available substitute drugs, health care centers can avoid the purchase of medications at a greatly increased price. Cincinnati Children's was required to purchase a supply of methylprednisolone during the current shortage from a pharmaceutical company with a price that was more than fivefold higher than the original contract price. In 2002, CCHMC ordered 672 grams of methylprednisolone at a cost of $23.44/gram, for an average yearly cost of $15,752. The inflated cost for methylprednisolone during the shortage was $125/gram, for an average yearly cost of $84,000. Introduction of the ICIS methylprednisolone alert resulted in a 55% relative reduction in use of this medication for an annualized savings of more than $36,000 (Table 2). The financial advantage of the ICIS alert limiting the use of the dwindling and expensive supply of methylprednisolone is clear. These financial advantages may, however, be unique to this situation, for it will not always be the case that a drug in short supply will have alternative drugs that are readily available.

Limitations

One possible limitation of this study is the limited time frame in which data were collected. The demand for corticosteroids varies during the year, and thus the results of this study may be valid only for the time period during which the study occurred. Another potential limitation of this study was the influx of new residents to this study's site in July after the alert was activated. It is possible that inexperienced physicians would follow the alert instructions more readily than experienced physicians. A study examining a longer time period would adjust for these potential confounders.

Conclusion

The dramatic results of this study indicate that a computer-based alert provides an efficient and cost-effective method of response to national drug shortages. It is likely that such computer-based prescribing alerts will provide future benefit in other important areas such as patient safety, consistency of care, cost–effectiveness, and education.

Table 2 ■ Projected Annual Savings from Methylprednisolone Prescribing Alert

	Control Period	Post-alert Period	Annualized Cost Difference (Control–Post-alert)
Methylprednisolone			
Number of orders (1 mo)	209	112	
Monthly usage (g)	56	30	
Cost per gram	$125	$125	
Monthly cost	$7,000	$3,750	
Estimated annual cost	$84,000	$45,000	$39,000
Dexamethasone			
Number of orders (1 mo)	702	937	
Monthly usage (g)	6	8	
Cost per gram	$81	$81	
Monthly cost	$486	$648	
Estimated annual cost	$5,832	$7,776	−$1,944
Hydrocortisone			
Number of orders (1 mo)	59	105	
Monthly usage (g)	4	7	
Cost per gram	$14	$14	
Monthly cost	$56	$98	
Estimated annual cost	$672	$1,176	−$504
Total projected annual savings	$90,504	$53,952	$36,552

References ■

1. American Society of Health-System Pharmacists. Glucocorticoids for injection. 2003. Available at: http://www.ashp.org/shortage/methylprednisolone.cfm?cfid=21191855&CFToken=5502695. Accessed: Dec 16, 2003.
2. Fox E, Tyler L. Managing drug shortages: seven years' experience at one health system. Am J Health Syst Pharm. 2003;60:245–53.
3. Landis N. Provisional observations on drug product shortages: effects, causes, and potential solutions. Am J Health Syst Pharm. 2002;59:2173–82.
4. Bates D, Leape L, Cullen D, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. JAMA. 1998;280:1311–6.
5. Fortescue E, Kaushal R, Landrigan C, et al. Prioritizing strategies for preventing medication errors and adverse drug events in pediatric inpatients. Pediatrics. 2003;111:722–9.
6. Raschke R, Gollihare B, Wunderlich T, et al. A computer alert system to prevent injury from adverse drug events. JAMA. 1998;280:1317–20.
7. King WJ, Paice N, Rangrej J, Forestell GJ, Swartz R. The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. Pediatrics. 2003;112:506–9.
8. Anderson JG, Jay SJ, Anderson M, Hunt TJ. Evaluating the capability of information technology to prevent adverse drug events: a computer simulation approach. J Am Med Inform Assoc. 2002;9:479–90.
9. Durieux P, Nizard R, Ravaud P, Mounier N, Lepage E. A clinical decision support system for prevention of venous thromboembolism. JAMA. 2000;283:2816–21.
10. Bates D, Kuperman G, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. Am J Med. 1999;106:144–50.
11. Evans R, Pestotnik S, Classen D, et al. A computer-assisted management program for antibiotics and other antiinfective agents. N Engl J Med. 1998;338:232–8.