

Immediate financial impact of computerized clinical decision support for long-term care residents with renal insufficiency: a case study

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The sponsor was not directly involved in the design, methods, subject recruitment, data collections, analysis, and preparation of manuscript.

Received 11 February 2011
Accepted 16 October 2011
Published Online First
18 November 2011

ABSTRACT

In a randomized trial of a clinical decision support system for drug prescribing for residents with renal insufficiency in a large long-term care facility, analyses were conducted to estimate the system's immediate, direct financial impact. We determined the costs that would have been incurred if drug orders that triggered the alert system had actually been completed compared to the costs of the final submitted orders and then compared intervention units to control units. The costs incurred by additional laboratory testing that resulted from alerts were also estimated. Drug orders were conservatively assigned a duration of 30 days of use for a chronic drug and 10 days for antibiotics. It was determined that there were modest reductions in drug costs, partially offset by an increase in laboratory-related costs. Overall, there was a reduction in direct costs (US\$1391.43, net 7.6% reduction). However, sensitivity analyses based on alternative estimates of duration of drug use suggested a reduction as high as US\$7998.33 if orders for non-antibiotic drugs were assumed to be continued for 180 days. The authors conclude that the immediate and direct financial impact of a clinical decision support system for medication ordering for residents with renal insufficiency is modest and that the primary motivation for such efforts must be to improve the quality and safety of medication ordering.

INTRODUCTION

Health information technology, through the implementation of computerized provider order entry with clinical decision support, has been increasingly identified as a means to improve medication safety.^{1–3} These systems are also expected to produce substantial reductions in healthcare costs. Individualized medication ordering recommendations for long-term care residents with varying levels of renal function is an ideal application of a clinical decision support system (CDSS), as renal impairment is common in this setting.^{4,5} For example, in a study of residents of 83 long-term care facilities in Ontario, Canada, among those aged 75 or older, it was determined that nearly a third had estimated creatinine clearances of <30 ml/min.⁶ Papaioannou and colleagues have reported results from a cross-sectional study of nursing home residents indicating that 40% had an inappropriate prescription for a drug based on creatinine clearance.⁷ This finding underscores the importance of this issue as a public health concern with policy implications. We have previously

reported that the implementation of a CDSS providing alerts and specific recommendations during the ordering of drugs for long-term care residents with renal insufficiency improved the quality of prescribing decisions.⁸

Currently, there is only limited information to support assessments of the business case for incorporating electronic medical records with computerized CDSSs in long-term care facilities.^{9–11} One component of this assessment is the immediate financial impact of increases and decreases in medication use and laboratory test orders. To assess this impact of a CDSS for medication ordering for residents of long-term care facilities with renal insufficiency, we tracked the differences in drug and laboratory test costs resulting from the changes made by physicians in medication ordering due to the alerts in a randomized trial.

CASE DESCRIPTION AND METHODS

The setting for this study was an academically affiliated long-term care facility in Canada with an electronic medical record system including integrated computerized provider order entry. The average age of residents was 86 years and 68% were female. Ten community-based physicians provided regular care to long-stay residents. Units are not assigned to physicians by specialty and there is frequent cross-over among units, as physicians and partners from their medical groups cover for colleagues on nights, weekends, and vacations. Physicians caring for residents had prior experience with CDSS. They provided care for residents in both intervention and control units.

The CDSS for dose and frequency of medication orders for long-term residents with renal insufficiency was developed by a team of physicians, pharmacists, and informatics professionals. Four categories of alerts were developed and implemented: (1) alerts presenting recommended doses; (2) alerts presenting recommended frequencies; (3) alerts recommending that the drug be avoided; and (4) alerts advising the prescriber that information required to calculate creatinine clearance was missing. In a randomized trial of the impact of the CDSS on the quality of prescribing, the 22 long-stay units of the facility were randomly assigned for prescribing physicians to receive or not receive the alerts.⁸

During the 12 months of the randomized trial, we captured in an audit file each alert that was displayed to a physician when starting to order a drug for a resident of an intervention unit, as well

as alerts triggered by initiation of drug orders for residents in the control units where alerts were not displayed. The audit file captured the drug that triggered the alert, with its dose and frequency and identifiers of the physician and patient. We also obtained data with full details on all drug orders that were submitted to the pharmacy so that we could compare each alert with all drugs actually ordered by that physician for that patient on that day. Thus we were able to identify all changes during the process of drug ordering that may have resulted from viewing alerts or second thoughts on the part of prescribers. We also captured information on serum creatinine tests with dates and results.

To estimate the direct and immediate drug- and laboratory-related financial impact of the CDSS, we compared the initial drug orders that triggered alerts for residents with the drug orders actually submitted for these residents on the day of the alert. We also identified orders for serum creatinine tests that were initiated within 1 day of receiving a relevant alert. For each alert, two research pharmacists reviewed the initial and submitted drug orders and used the information on drug name, dose, and duration to assign unit costs based on the US wholesale price at the time.¹² Drug orders were conservatively assigned a duration of 30 days of use for a chronic drug and 10 days for antibiotics. As duration of use of many drugs may vary substantially in this setting, we also performed a sensitivity analysis, assigning durations of use of 90 and 180 days for non-antibiotic drugs. When an alert recommending avoidance of a drug led to that drug not being ordered, the pharmacists identified any drugs ordered for the patient on that day that could have served as substitutes for the drugs that were not ordered, and assigned unit costs to these drugs. Costs for recommended serum creatinine test orders were estimated on the basis of Medicare-allowable payments, which ranged at the time from US\$7 to US\$13 depending on the specific type of test ordered.

As a preliminary estimate of the direct and immediate impact of the CDSS on costs, we compared the costs for the drug orders as they were initiated with costs for the final submitted drug orders after an alert had been received in the intervention units. In the control units, there were also differences between the initial and final submitted drug orders, suggesting that changes in drug orders during prescribing were not always due to receiving an alert. We do not know the circumstances that led to these changes in drug orders in the control units. We suspect that they varied and in some cases involved a purposeful reconsideration of the initial order before finalization, based on

recognition of the resident's level of renal impairment. For example, we observed instances where the dosage of H₂ antagonist therapy or quinolone antibiotic therapy was reduced without an alert having been displayed. Importantly, we compared costs for the initial and final submitted drug orders in the control units and used these results to adjust the estimates for the intervention units. We summed the resulting differences within alert categories and across the entire CDSS. For alerts advising the prescriber of missing creatinine values, we calculated the cost of creatinine tests within 1 day of the alert. As a sensitivity analysis, we also estimated the costs and savings using 90- and 180-day durations for non-antibiotic drugs.

To assess the relevance of the study findings for the USA, we extrapolated the cost savings from the study site to the US nursing home setting. Data from the most recent National Nursing Home Survey were used to derive the characteristics of US nursing home facilities including average bed sizes and occupancy rates.¹³ We calculated cost saving per resident-day in the Canadian long-term care study facility and then extrapolated potential savings to the USA by estimating resident-days using bed size multiplied by occupancy rates. Given the large variation in the size of nursing homes in the USA, we estimated cost savings for facilities based on size: fewer than 50 beds, 50–99 beds, 100–199 beds, and more than 200 beds. We therefore report the potential financial impact within bed-size categories and for the average-bed-size nursing home in the USA. To provide a basis for understanding the potential savings related to different rates of renal insufficiency within a nursing home, we calculated the percentage of the residents in the intervention and comparison units who had a creatinine clearance level of <60 ml/min per 1.73 m² of body surface area at any time during the year of observation.

RESULTS

During the 12 months of the study, there were a total of 107 856 resident-days in the intervention units and 106 111 in the control units. The prevalence of chronic kidney disease defined as a creatinine clearance <60 ml/min was the same among residents of both intervention and control units (81%).

Physicians prescribing drugs for residents in the intervention units received 274 alerts during the initiation of drug orders (a rate of 2.5 per 1000 resident-days); 257 alerts were triggered, but not displayed to physicians, on the control units (a rate of 2.4 per 1000 resident-days). Table 1 compares the cost of the initial orders with the final submitted orders in the intervention and control units. Within the intervention units, initial drug

Table 1 Cost of initial orders compared with actual submitted orders

Type of alert	Intervention units				Control units				Cost difference Intervention cost difference – control cost difference for medication orders; Intervention cost – control cost for test orders
	Cost as started to order (US\$)	Cost of submitted drug orders or added test orders (US\$)	Cost difference (US\$)	%	Cost as started to order (US\$)	Cost of submitted drug orders or added test orders (US\$)	Cost difference (US\$)	%	
Dose	15897.11	13334.09	2563.02	16.1	9243.53	8722.54	520.99	5.6	2042.03
Frequency	795.68	733.38	62.30	7.8	648.36	581.93	66.43	10.3	–4.13
Avoid	1664.73	1106.23	558.50	33.6	2276.29	1840.16	436.13	19.2	122.37
All drug orders	18357.52	15173.70	3183.82	17.3	12168.18	11144.63	1,023.55	8.4	2160.27
Missing information (creatinine test orders)		1048.42				279.58			768.84
Total cost difference									1391.43

orders that triggered alerts about recommended doses had the highest overall total drug costs, and these alerts were associated with a reduction in drug costs for the final submitted orders of US\$2563.02. For the control units, spontaneous changes in drug orders under situations that would have triggered alerts, but which did not display, resulted in a reduction of US\$520.99. Combining these results produces an estimated net reduction in drug costs associated with dose alerts of US\$2042.03. Comparable analyses for the frequency alerts indicated an increase in drug costs of US\$4.13. For avoid alerts, there was an estimated net reduction in costs of US\$122.37. For alerts recommending the need for serum creatinine testing, the total difference in laboratory-related costs was US\$768.84. Overall, during the 12-month period, we estimated that direct costs were reduced by US\$1391.43, a net 7.6% reduction. Sensitivity analyses using 90- and 180-day durations of use indicated reductions in direct costs of US\$4034.18 (a net reduction of 12.5%) and US\$7889.33 (a net reduction of 15.0%), respectively.

The per-resident year estimate of cost reduction is US\$4.71. Sensitivity analyses for 90- and 180-day durations of use provided per-resident year reductions of US\$13.66 and US\$27.09. Thus extrapolation of the impact on costs of incorporating medication ordering for long-term care residents in US nursing homes suggests overall cost reductions that range from US\$131 in facilities with fewer than 50 beds to US\$1038 in facilities with more than 200 beds (table 2). The average bed size of a nursing home in the USA is 108, with an estimated annual cost reduction of US\$444. This reduction would differ for nursing homes with different rates of renal insufficiency. We found that 81% of the residents in this facility had creatinine clearance below 60 ml/min at some point during the 1 year of the study. A cross-sectional study that measured creatinine clearance at 83 long-term care facilities at a single point in time found one-third to have creatinine clearance levels below 30 ml/min,⁶ suggesting that the rates in our study are not unusual.

DISCUSSION

In the present study, implementation of a CDSS to generate alerts during medication ordering for patients with impaired renal function had minimal impact on direct and immediate costs. Overall, there was a reduction in costs of US\$1391.43 over a 12-month period in the study site, a net 7.6% reduction. This translates to less than US\$450 annually for the average nursing home in the USA, or US\$4.71 per resident-year. Sensitivity analyses extending duration of use of ordered drugs to 180 days, increased the per resident-year estimate to US\$27.09.

We previously reported that the cost of developing and implementing a CDSS for guided medication dosing for patients with renal insufficiency was US\$48 669, and we estimated the cost of implementing an existing CDSS for this issue at US\$23 695.¹⁴ On the basis of the direct and immediate cost

reduction estimated in the present study, it would take an extended period of time to recoup the initial investment for development of the CDSS. It is important to emphasize that we did not include reductions in costs associated with preventing adverse drug events that could have been precipitated by inappropriate drug orders, as these events were not tracked for this study.

Our prior work relevant to the long-term care setting has indicated that adverse drug events occur at a rate of nearly 100 per 1000 resident-months, with renal/electrolyte adverse events occurring at a rate of 10 per 1000 resident-months.¹⁵ Half of these renal/electrolyte events are associated with medication errors. These rates of adverse drug events, and the fortunate fact that very few medication errors result in drug-related injuries to patients,¹⁶ present substantial challenges in assessing the true financial impact of computerized clinical decision support-based interventions on patient outcomes in the context of a single-facility study. It is essential to emphasize that the prevention of even one serious adverse drug event, especially one leading to prolonged hospitalization, would dramatically increase the modest cost savings estimates presented in this paper.

One potential limitation of the study is that seeing alerts in the intervention units may have influenced physicians' prescribing in the control units. However, in a previous study of physician responses to alerts in a similar long-term care facility, we found that prescribing in the control units did not improve over a 1-year period of the study.¹⁷

The findings of this economic assessment indicate that a CDSS for residents of long-term care facilities with renal impairment impacts minimally on immediate and direct costs. We conclude that neither a reduction nor an increase in costs should be considered part of the rationale for, or the argument against, implementing such systems in the long-term care setting. The primary motivation for such efforts must be to improve the quality and safety of medication ordering.

Funding This project was supported by grants from the Agency for Healthcare Research and Quality (HS010481 and HS15430).

Competing interests None.

Ethics approval University of Massachusetts Medical School.

Contributors SS, JHG, and TSF collaborated in designing the study, interpreting the results, and preparing the manuscript. SH, JLW, JLD, and AOK all assisted with data acquisition and analysis. PAR facilitated acquisition of data and interpreting the results.

Provenance and peer review Not commissioned; externally peer reviewed.

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Table 2 Annual financial impact of incorporating renal medication ordering alerts in US long-term care facilities

Type of alert	Per bed per year	Fewer than 50 beds	50–99 beds	100–199 beds	200 beds or more
Dose	6.92	11.49	29.12	47.72	91.26
Frequency	–0.01	–0.39	–0.98	–1.61	–3.08
Avoid	0.41	191.77	485.98	796.34	1522.87
Missing creatinine	–2.60	–72.70	–182.98	–299.83	–573.37
Total	4.71	130.67	331.15	542.62	1037.67

Values are US dollars.

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