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Impact of a Real-Time Computerized Duplicate Alert System on the Utilization of Computed Tomography

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The use of high-cost imaging modalities is rising rapidly. From 1995 through 2007, use of computed tomographic (CT) scans in the United States increased more than 4-fold[1,2]; by 2006, CT and magnetic resonance imaging examinations were the fastest-growing physician-directed Medicare expenditure.[3,4] An uncertain proportion of these examinations represent overuse.[5]

There are little published data on the frequency of duplicated high-cost imaging examinations,[6] but economic modeling suggests that cost savings from reducing redundant radiologic testing would be substantial.[7] Because unnecessary duplication of CT examinations contributes to an increasingly strained medical payment system and exposes patients to unnecessary potential risks of radiation and intravenous contrast,[2,8,9] we sought to determine whether alerting an ordering health care provider to the presence of a potentially redundant recent CT examination via decision support in a computerized physician order entry system (CPOE) can reduce repeated testing.

Methods

Institutional review board approval was obtained for this prospective controlled trial, performed at Brigham and Women's Hospital, a 752-bed urban tertiary academic medical

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Author Contributions: Dr Wasser and Ms Mar had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Wasser, Prevedello, Sodickson, and Khorasani. *Acquisition of data:* Wasser and Mar. *Analysis and interpretation of data:* Wasser, Sodickson, Mar, and Khorasani. *Drafting of the manuscript:* Wasser. *Critical revision of the manuscript for important intellectual content:* All authors. *Statistical analysis:* Wasser and Mar. *Obtained funding:* Khorasani. *Administrative, technical, and material support:* Khorasani. *Study supervision:* Prevedello and Sodickson.

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center in Boston, Massachusetts. We entered all CT orders initiated in the CPOE system (Percipio; Medicalis Corp) from January 1, 2010, through May 31, 2010, that resulted in display of an intravenous contrast risk questionnaire at the time of order entry (approximately 98% of all CT orders placed during the period). Duplicate decision support (DDS) alerts the ordering provider to a potentially redundant recent CT (one performed on the same body part within 90 days of the index CT order). Links to images and radiology reports for these prior CT examinations are displayed. Following the alert, the user may proceed with, cancel, or abandon the order.

Information regarding orders and ordering health care providers was collected via the order entry system including patient age and sex, the clinical setting, examination type, and body part imaged. User cancellation events were recorded by the CPOE system. In addition, 200 CT orders were randomly selected: half that had triggered the DDS logic and half that had not. The appropriateness of DDS triggering was assessed by manually comparing these with the record of prior CT examinations in the electronic medical record.

The intervention group included CT orders for which both the DDS and contrast questionnaire were presented; the control group included those CT orders displaying the contrast questionnaire only. The primary outcome measure was the proportion of CT orders cancelled following DDS presentation. True cancellations were those cancelled or abandoned by the user at the time of entry and not reordered within 24 hours. Cancellation rates were defined as the ratio of true cancellation events to the total number of CT orders.

The DDS algorithm was assessed by calculation of sensitivity, specificity, accuracy, and positive and negative predictive value. We estimated 95% confidence intervals using the Wilson score method and statistical significance by practice setting using a χ^2 analysis. Statistical analyses were performed using JMP9 software (SAS Institute).

Results

Compared with manual medical chart review, the DDS alert was 96.9% sensitive (95% CI, 0.91–0.99) and 93.3% specific (95% CI, 0.87–0.97) with a positive predictive value of 93.0% (95% CI, 0.89–0.97), negative predictive value of 97.0% (95% CI, 0.92–0.99), and accuracy of 95.0% (95% CI, 0.92–0.98).

A total of 34 625 CT orders were initiated during the study period. After eliminating scans for research or administrative purposes, 33 523 clinical CT orders remained. Approximately one-third of these (33.6%) had a recent potentially redundant CT examination, triggering the DDS alert. The intervention group comprised the 11 074 orders activating both the DDS and contrast safety questionnaire. Within the remaining 24 596 CT orders, 21 784 (65.0%) activated the questionnaire alone and comprised the control group. Patient age and sex were similar across the intervention and control groups.

Presenting an alert at the time of order entry resulted in a significantly higher proportion of canceled CT orders compared with CT orders not triggering the alert (6.0% [661 of 11 074] vs 0.9% [194 of 22 281], or a greater than 6-fold increase; $P<.001$) across all practice settings (Table 1 and Table 2). The odds ratio of order cancellation differed by practice

setting, ranging from 19.3 (95% CI, 10.3–36.1) in the primary care clinic to 4.0 (95% CI, 2.8–5.9) in the outpatient surgical clinics.

Discussion

In our study, for nearly one-third of CT orders attempted, a CT examination had been performed on the same body part in the prior 90 days. A CPOE-embedded DDS notifying ordering health care providers of these potentially redundant examinations resulted in a 5.1% CT order cancellation rate attributable to DDS. The net effect was cancellation of 1.7% of all CT orders placed during the study period (33.6% × 5.1%). Given the large number of CT studies performed in the United States, even small reductions in unnecessary duplication could prove beneficial. If our findings are confirmed by others, using decision support to notify providers to the presence of recent similar imaging studies may be an effective tool to reduce waste while improving patient safety.

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Table 1

Basic Demographic Characteristics of Patients Undergoing Computed Tomography During the Data Collection Period and Cancellation Rates Following Presentation of Duplicate Decision: Support Alert vs Control

Characteristics	Duplicate Decision Support Alert		Control Alert	
Orders, Total No.	11 577		23 048	
Clinical orders (nonresearch), Total No.	11 262		22 281	
Clinical orders with contrast questionnaire, Total No.	11 074		21 784	
Age, mean (range), y	60.0 (14–102)		59.1 (9–103)	
Male, %	47.2		45.7	
	Completed Order	**Cancelled**	**Completed Order**	**Cancelled**
Orders, No. (%)	10 413 (94.0)	661 (6.0)	21 590 (99.1)	194 (0.9)
Age, mean (range), y	60.0 (14–102)	59.3 (14–92)	59.4 (9–103)	57.5 (9–96)
Male, %	46.7	48.4	45.6	47.4

Table 2

Cancellation Rates With and Without Duplication Decision Support (DDS) With Comparison to Control Group

	No. (%)				
			Cancellation		
Practice Setting	**Total CT Orders**	**DDS Activation**	**DDS**	**Control**	**OR (95% CI)[a]**
Primary care clinic	1911 (5.8)	102 (5.3)	21 (20.6)	24 (1.3)	19.3 (10.3–36.1)
Medical specialty clinic	2376 (7.2)	410 (17.3)	62 (15.1)	24 (1.2)	14.4 (8.9–23.4)
Inpatient units	7645 (23.3)	2688 (35.2)	156 (5.8)	25 (0.5)	12.2 (8.0–18.6)
Emergency department	5776 (17.6)	600 (10.4)	44 (7.3)	36 (0.7)	11.3 (7.2–17.7)
Outpatient cancer center	10 938 (33.3)	5231 (47.8)	251 (4.8)	50 (0.9)	5.7 (4.2–7.7)
Surgical specialty clinic	4212 (12.8)	2043 (48.5)	127 (6.2)	35 (1.5)	4.0 (2.8–5.9)
Total	**32 858** (100)	**11 074** (33.9)	**661** (6.0)	**194** (0.9)	7.1 (6.0–8.3)

Abbreviations: CT, computed tomographic; OR, odds ratio.

[a] P <.001 for all comparisons.