eAppendix

1. Clinical Decision Support Alert Selection and Development

Choosing Wisely (CW) recommendations were evaluated for integration appropriateness into the electronic health record (EHR), based on workflow relevance (the ability to trigger an alert at the time and place of decision making) and technical feasibility (the presence of data elements necessary to target the recommendation).

Clinicians from Stanson Health reviewed the primary evidence sources provided by the medical specialty societies as support for the CW recommendations. Using this evidence, the clinicians defined inclusion and exclusion criteria for triggering an alert to providers that an order is potentially in conflict with a CW recommendation and, as such, may be unnecessary or inappropriate for a given patient. More than 30 discrete data elements from the EHR, including patient age, gender, diagnosis, medications, vital signs, and lab results are utilized by the clinical decision support rules.

Alerts are evaluated by clinician chart review to determine false-positive rates. Using feedback from chart review and provider overrides, the alerts are modified over time to increase sensitivity or specificity.

Alert outcomes are categorized as "followed," "overridden," or "ignored." For alerts addressing order appropriateness, such as those included in this study, followed alerts are those in which the trigger order was not signed within 1 hour after the alert was shown to a provider. Overridden alerts are those in which a provider selected a predefined override reason from the EMR interface and proceeded with the order. Ignored alerts are those in which a provider did not provide an override reason and signed the trigger order within 1 hour of seeing the alert. In this study, overridden and ignored alerts were considered to be in the same category. In order to be included, alerts had to fire at least once per month and need not have been active the entire study period (eAppendix Table 1).

eAppendix Table 1. Choosing Wisely Alerts Included in the Clinical Decision Support Analysis

Alert Name	Choosing Wisely Recommendation	Authoring Society
Antipsychotics for insomnia adult	Don't routinely prescribe antipsychotic medications as a first-line intervention for insomnia in adults.	American Psychiatric Association
Antipsychotics in dementia patients	Don't use antipsychotics as first choice to treat the behavioral and psychological symptoms of dementia.	American Geriatrics Society
Appetite stimulants in older adults	Avoid using prescription appetite stimulants or high-calorie supplements for treatment of anorexia or cachexia in older adults; instead, optimize social supports, discontinue medications that may interfere with eating, provide appealing food and feeding assistance, and clarify patient goals and expectations.	American Geriatrics Society
Benzodiazepines and sedatives for patients older than 65†	Don't use benzodiazepines or other sedative-hypnotics in older adults as first choice for insomnia, agitation, or delirium.	American Geriatrics Society

Blood transfusion in patients with Hgb greater than 7 g/dL*	Don't transfuse more than the minimum number of red blood cell (RBC) units necessary to relieve symptoms of anemia or to return a patient to a safe hemoglobin range (7- to 8 g/dL in stable, noncardiac inpatients).	American Society of Hematology
Brain imaging for simple syncope	In the evaluation of simple syncope and a normal neurological examination, don't obtain brain imaging studies (CT or MRI).	American College of Physicians
Cardiac imaging for chest pain patients at low risk	Don't perform cardiac imaging for patients who are at low risk.	American Society of Nuclear Cardiology
Carotid artery imaging for simple syncope*	Don't perform imaging of the carotid arteries for simple syncope without other neurologic symptoms.	American Academy of Neurology
Chest x-ray at regular intervals†	Don't order diagnostic tests at regular intervals, such as every day, but rather in response to specific clinical questions.	Critical Care Societies Collaborative - Critical Care
CT angio for pulmonary embolism in young women*	Avoid using a computed tomography angiogram to diagnose pulmonary embolism in young women with a normal chest radiograph; consider a radionuclide lung study ("V/Q study") instead.	Society of Nuclear Medicine and Molecular Imaging
Erythropoiesis stimulating agents	Don't administer erythropoiesis-stimulating agents (ESAs) to patients with chronic kidney disease (CKD) with hemoglobin levels greater than or equal to 10 g/dL without symptoms of anemia.	American Society of Nephrology
Imaging for pulmonary embolism when pretest risk is low*	In patients with low pretest probability of venous thromboembolism (VTE), obtain a high-sensitive D-dimer measurement as the initial diagnostic test; don't obtain imaging studies as the initial diagnostic test.	American College of Physicians
Lyme disease testing	Don't test for Lyme disease as a cause of musculoskeletal symptoms without an exposure history and appropriate exam findings.	American College of Rheumatology
NSAIDS in hypertension heart failure or CKD patients*†	Avoid nonsteroidal anti-inflammatory drugs (NSAIDS) in individuals with hypertension or heart failure or CKD of all causes, including diabetes.	American Society of Nephrology
Repeat ultrasound for DVT	Don't reimage DVT in the absence of a clinical change.	Society for Vascular Medicine
Routine 25-OH-vitamin D deficiency screening	Don't perform population-based screening for 25-OH-vitamin D deficiency.	American Society for Clinical Pathology

Stress ulcer prophylaxis medications for low-risk patients*†	Don't prescribe medications for stress ulcer prophylaxis to medical inpatients unless at high risk for GI complications.	Society of Hospital Medicine - Adult Hospital Medicine
T3 levels in hypothyroid patients*	Don't order a total or free T3 level when assessing levothyroxine (T4) dose in hypothyroid patients.	Endocrine Society

Alerts listed above and denoted with an asterisk (*) are configured in the Cedars-Sinai EMR as "medium stops," meaning that a user cannot close the alert window until they either remove an inappropriate order or select one of the override reasons provided. Alerts denoted with a dagger (†) evaluate information entered during the ordering process and trigger when the order is signed; all other alerts rely entirely on information already in the chart and trigger when the order is initially entered.

eAppendix Table 2. Characteristics of All Patients by Alert Status

Characteristics	**Alert Adherence (n = 1591)[a]**	**Alert Nonadherence (n = 24,833)**	**Mixed Alert Adherence (n = 1810)**	**No Alert Received (n = 53,548)**
Women, n (%)	880 (55.3%)	13112 (52.8%)	954 (52.7%)	30637 (57.2)
Age, mean (SD), years	65.9 (18.7)	65.7 (18.3)	67.0 (18.2)	48.8 (27.7)
Level 1 - Minor, n (%)	254 (15.96%)	3648 (14.69%)	153 (8.50%)	19991 (37.3%)
Level 2 - Major, n (%)	510 (32.06%)	7574 (30.50%)	403 (22.20%)	18065 (33.7%)
Level 3 - Severe, n (%)	562 (35.32%)	8945 (36.02%)	641 (35.40%)	11667 (21.8%)
Level 4 - Extreme, n (%)	280 (17.60%)	4848 (19.52%)	613 (33.90%)	3821 (7.1%)
Number of diagnoses, median (IQR)	15 (7.0)	15 (6.0)	16 (7.0)	8 (4.0)
Expected length of stay, median (IQR)	3.9 (2.2)	4.1 (2.8)	4.8 (3.8)	3.2 (1.9)
Elixhauser index, median (IQR)	2.6 (2.7)	2.7 (2.7)	2.9 (2.8)	1.9 (2.2)
Case mix index, median (IQR)	1.6 (1.4)	1.7 (1.8)	1.8 (1.8)	1.2 (1.1)
Medicare status	63.0%	63.0%	67.6%	38.7%
30-day readmissions rate	17.8%	20.0%	19.0%	10.5%
Complications rate	6.70%	10.0%	15.3%	5.0%
Length of stay, days, median (IQR)	4.0 (5.0)	5.0 (6.0)	8.0 (8.0)	3.0 (3.0)

IQR indicates interquartile range.

[a]Number of encounters.

eAppendix Table 3. Characteristics of Providers by Alert Status

Characteristics of Providers Receiving Alerts	Total Alerts Received	% Alert Adherence	% Alert Nonadherence
Overall cohort	42,081	9.7%	90.3%
Overall cohort median (IQR)	4 (11.15)	9.7%	90.3%
Characteristics of Providers by Quintile Membership (Ordered by Total Alerts) Received			
First quintile (lowest alerts received)	640	13.8%	86.2%
Second quintile	1204	14.3%	85.7%
Third quintile	2483	13.8%	86.2%
Fourth quintile	5377	12.5%	87.5%
Fifth quintile (highest alerts received)	32,395	8.7%	92.3%
Characteristics of Top 10 Providers by Most Alerts Received (>200 alerts)			
Provider 1	695	4.3%	95.7%
Provider 2	540	13.0%	87.0%
Provider 3	332	4.8%	95.2%
Provider 4	279	0%	100%
Provider 5	269	7.4%	92.6%
Provider 6	249	4.8%	95.2%
Provider 7	238	16.8	83.2%
Provider 8	235	13.2%	86.8%
Provider 9	220	4.5%	95.5%
Provider 10	209	5.7%	94.3%

IQR indicates interquartile range.

[a] Includes encounters with mixed alerts status.

2. Notes on Cost Accounting Methodology

The year-to-date general ledger cost is loaded into the cost accounting application and broken into 3 categories of 1) patient care, 2) overhead, and 3) reconciling departments. Within patient care departments, the costs of direct administrative cost centers, pure cost holding cost centers (no revenue is booked to these cost centers), and academic cost centers are reclassified into patient care cost centers containing patient revenue. After this reclassification, the overhead cost center groups allocate their costs to other overhead groups (through reciprocal allocation) and direct patient care cost centers. At this point, all patient care cost centers have their direct and overhead cost components that are ready to be assigned to chargeable activities.

Through a separate data load, all of the chargeable activities from the patient care cost centers are loaded from data warehouses into the application based on posting dates matching the period date of general ledger data originally loaded into the system. An average price per chargeable activity is calculated to smooth out price list differences related to service date that could transcend the date limits of costing period or related to intra-period price changes.

After collecting the direct and overhead costs for a period and the matching volume and revenue by chargeable activity for the same period, the cost is assigned to the activities based on the cost component assignment methodologies. These costs are then rolled up by patient account to develop encounter level costs. The process of cost reconciliation against the general ledger consists of matching the starting point general ledger total cost against the sum of total cost (direct and overhead) for all chargeable activities, with posting dates during the period and the cost residing in the reconciling cost centers.

3. Notes on Regression Methods

The statistical performance of the regression models was evaluated on several metrics. The logistic regression models were evaluated using the C-statistic computed from the area under the receiver operating characteristic curves. The quality of fit of the model was assessed using the Hosmer-Lemeshow goodness of fit (GOF) test, which determines whether observed event rates match expected event rates in subgroups of the data population. The number of subgroups to use for the Hosmer-Lemeshow GOF test is recommended to be the number of covariates +1.[1] The error distribution for the logistic models was assumed to be Bernoulli. The link function used was the logit function. GOF of the 2 log-linear models was assessed using the adjusted R-squared. The error distribution was assumed to be Gaussian.

References

1. Hosmer DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*. 3rd ed. Hoboken, NJ: Wiley; 2013.