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Closing the Loop on Unscheduled Diagnostic Imaging Orders – A Systems-Based Approach

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Abstract

Objective: To: 1) describe a System for Coordinating Orders for Radiology Exams (SCORE) which aims to manage unscheduled orders for outpatient diagnostic imaging in an electronic health record (EHR) with embedded computerized physician order entry (CPOE), 2) assess the impact of SCORE and other related factors (e.g., demographics) on rate of unscheduled orders, and 3) assess the clinical necessity of orders canceled, expired, scheduled and performed.

Methods: This Institutional Review Board-approved retrospective study was conducted in a large academic institution between 10/1/2017–7/1/2019. The design and implementation of SCORE is described, including people (e.g., competencies), processes (e.g., standardized procedures) and tools (e.g., EHR interfaces, dashboard). Rate of unscheduled imaging orders was compared pre-SCORE (10/1/17–9/30/18) and post-SCORE (10/1/18–6/30/19) using chi-square analysis. For 447 randomly selected orders, mode of resolution was obtained from the EHR and factors related to order resolution were assessed via multivariable analysis. Finally, clinical necessity was manually assessed by two physicians.

Results: Pre-SCORE, 52,204/607,020 exam orders were unscheduled (8.6% of orders), compared to 20,900/475,000 exam orders (4.4% of orders) post-SCORE (χ^2, $p<0.00001$), a 49% reduction in unscheduled orders. Among 447 randomly selected orders, orders were addressed via cancellation (57%), expiration (21%), scheduling (1%) and performance (11%). Order resolution

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was not significantly associated with other factors. 31.9% of cancellations and 27.7% of expired orders remained clinically necessary and were attributed to scheduling and patient-related factors.

Conclusion: SCORE significantly reduced unscheduled diagnostic imaging orders. This patient safety initiative may help reduce errors resulting from diagnostic delays due to unscheduled exam orders.

Keywords

Medical order entry systems; diagnostic imaging; diagnostic errors; delayed diagnosis; patient safety

Introduction

Clinically necessary diagnostic imaging orders that remain unscheduled represents an important risk factor for diagnostic delays in medicine.(1) In a human factors analysis of various information sources to inform diagnostic process errors, the electronic health record (EHR) and computerized physician order entry (CPOE) system were demonstrated to contain unscheduled orders for diagnostic imaging examinations that were potential safety events.(1) These events included unscheduled orders that were clinically necessary for acute, episodic or follow-up care, clinically unnecessary duplicate orders, and duplicate orders created during exam planning by radiologists (protocoling). In a follow-up study, 7% of all diagnostic radiologic examination orders remained unscheduled at least a month after they were placed.(2) In most imaging modalities, the majority of unscheduled orders were clinically necessary. Given the large volume of radiological examinations ordered annually nationwide,(3–5) this represents a substantial number of potential diagnostic delays. Thus, proactively addressing unscheduled radiology orders in the EHR represents a potentially major opportunity to reduce diagnostic errors.

In its 2000 landmark report, “To Err Is Human: Building a Safer Health System”(6, 7), the Institute of Medicine (now the National Academy of Medicine) cited diagnostic errors as an issue but did not make widespread improvement recommendations. Thus, in their September 2015 “Improving Diagnosis in Health Care”, they specifically addressed diagnostic failures, defining them as “the failure to establish an accurate and timely explanation of the patient’s health problem(s) or communicate that explanation to the patient.”(8) Delays in diagnostic evaluation have been identified as a key component of diagnostic failure and can often lead to inadequate patient management. Specifically, the role of radiological imaging in diagnosis has greatly expanded in the last decades(3–5) and includes examinations clinically necessary for acute episodic care, as well as those to expedite the diagnostic and prognostic processes.

We developed an institution-wide, multidisciplinary and multifaceted quality improvement intervention – a System for Coordinating Orders for Radiology Exams (SCORE) – to address unscheduled orders and ensure that every order placed is ultimately resolved (e.g., performed) in a timely fashion. In this study, we describe SCORE and assessed its impact on the prevalence of unscheduled radiologic examination orders in an EHR. We also assessed related factors that may be associated with order resolution. In addition, we quantified the

proportion of clinically necessary orders among orders that were scheduled compared to those that were canceled or expired.

Methods

Study Design and Setting

This Institutional Review Board–approved, retrospective cohort study was conducted at a 793-bed, urban, academic hospital performing ~600,000 imaging examinations for 44,000 inpatient admissions, 950,000 ambulatory visits, and 54,000 Emergency Department visits annually. Diagnostic radiology orders are placed in the EHR with embedded CPOE system (Epic Systems Corporation, Madison, Wisconsin). Orders expire at default intervals; 24 months for mammographic and bone density examinations and 12 months for all other imaging examinations.

System for Coordinating Orders for Radiology Exams (SCORE)

Overview: SCORE was inspired by Donabedian's quality of care framework and focuses on structures and processes in order to improve health outcomes.(9) The diagnostic process often involves intra- and inter-professional teamwork in a complex healthcare setting as part of these structures and processes.(10) SCORE provides a "safety net" for patients unable to complete the diagnostic process expeditiously. The system tracks all patients with a radiological examination ordered for acute, episodic, or follow-up management. When the system fails and an examination order is not resolved within the time frame specified by the ordering provider, SCORE detects and manages the order.

Personnel and Initial Development: SCORE includes a multi-disciplinary project core team with Medicine and Radiology clinicians and care coordination and management specialists, is governed by a multidisciplinary Steering Committee, and works with analytical teams (Figure 1). Care coordinators and management specialists include schedulers and individuals dedicated to obtaining pre-authorization for scheduled exams from payers. Full time equivalent (FTE) new hires to support this initiative included six schedulers and 8 pre-authorization specialists to supplement existing teams of 13 schedulers and 20 pre-authorization FTEs. The Radiology Vice Chair for Quality and Safety, and the institution's Chief Medical Information Officer for ambulatory services provide clinical oversight for this initiative as active members of the Steering Committee. Additional support from the institution includes the hospital's Chief Operating Officer, chairpersons of clinical departments, the Executive Director for Ambulatory Services, the Associate Director of the physician practice organization, the Chief Medical Officer, and the Chief Information Officer.

Processes and Models: SCORE uses a combination of two models; a Central Model and a Local Model. Each ambulatory practice site and hospital department selected a model prior to SCORE roll-out, although most were encouraged to use the Central Model via earlier access to trained care coordinators.

The Local Model refers to the traditional approach whereby local practice staff manage all scheduling aspects for radiology orders. A practice is responsible for scheduling all diagnostic imaging examinations ordered for their patients without involvement of SCORE care coordinators until the end of each order's prescribed time frame (e.g., chest CT scan for lung nodule follow-up in 12 months). When no examination is performed, the local practice is contacted by coordinators, but order scheduling remains the responsibility of local practices unless they ask the care coordinators to take over the responsibility.

In the Central Model, each practice and department can still schedule examinations in the first 24 hours after order creation. However, after this time, a single centrally managed care coordinating team become responsible for contacting patients to schedule all unscheduled orders, including new orders and previously scheduled orders that were deferred and never rescheduled. For the latter, patients are contacted a month prior to the order's prescribed time frame (unless the order's time frame is ≤ 1 month from the time it was created, in which case the care coordinators contact patients a week prior to the prescribed time).

Tools: Care coordinators work from work queues of all orders which are standard components of the Epic scheduling module, locally configured by the IT team. Elements of the order include the imaging modality, the prescribed time frame, and order status (e.g., performed, scheduled). The work queue displays a list of all unresolved orders.

Workflow: The care coordinators monitor all orders daily and are responsible for ensuring that all orders are ultimately resolved. Order resolution statuses include performed, scheduled, canceled, and expired. As orders expire, the ordering provider is sent an electronic alert with an option to re-order an examination if necessary. Performed orders are those already completed, scheduled orders are those for which the examination had been scheduled for a specific date but not yet performed, canceled orders are those canceled for any reason, and expired orders are those that had expired and were not renewed by the orderer - these are displayed on the work queue but require no further action from schedulers. All other remaining orders are pending and need to be scheduled or canceled by the schedulers (Figure 2). If a patient is deceased or decides to have an exam at an outside practice, the order is canceled, and a notification message is sent to the ordering provider. If a patient is unreachable after three attempts, the order is deferred for 28 days, and a letter is sent to the patient to allow them time to schedule the order. After 28 days and if the patient remains unreachable, the order is canceled, and a message is sent to the ordering provider.

Process metrics for the care coordinators and the Steering and Executive committees are displayed in real-time on a dashboard. For the Steering and Executive Committees, for example, Figure 3 illustrates total orders that are unscheduled in a specific month, and those that care coordinators in Central Scheduling have worked on. A breakdown of orders according to their order resolution status is specified in the display.

Study Cohort Identification

To assess the impact of SCORE, we identified all radiologic examination orders placed during a study period between October 1, 2017 and July 1, 2019. Orders for nuclear medicine and interventional radiology examinations were excluded to focus primarily on

non-interventional imaging exams. Orders placed 10/1/17–9/30/18 were classified as pre-SCORE; those 10/1/18–6/30/19 classified as post-SCORE.

Classifying Orders

From the study cohort, 447 orders were randomly selected and assigned across three individual reviewers (a physician who is a radiology research fellow, a senior attending radiologist and a senior attending internist) for classification as to how the orders were resolved and of clinical necessity. 6% of orders were reviewed together to determine inter-annotator agreement with final adjudication based on consensus. Orders were classified into one of four order resolution categories - performed, scheduled, canceled, and expired by October 1, 2019 (at least 3 months from order creation).

Performed orders are those completed during the study period. Scheduled orders were those for which the examination had been scheduled for a specific date but not yet performed at time of review. Canceled orders were those canceled during the study period for any reason. Expired orders were those that had expired and not been renewed by the orderer. Factors that may be associated with unscheduled orders were obtained from the institutional research data repository and included patient-specific features (i.e., age, sex, race, ethnicity, and insurance coverage), ordering clinic specialty (medicine vs. others), and imaging modality.

The manual reviews also classified each order as to whether it remained clinically necessary. Clinically necessary orders were defined previously(2) as those for (1) follow-up, (2) acute or episodic care, or (3) duplicate or repeating orders of the same examination that remain clinically necessary when none of the prior orders have been scheduled and performed. Clinical necessity was assessed based on the ordering providers' perceived intent, rather than based on appropriateness of the ordering provider's clinical decision.

Sample size of 447 orders was based on a range between 280 to 500 orders, calculated to provide 95% to 99% confidence level that the true margin of error is within 2.5% of our results,(11) with 5.2% expected prevalence of unscheduled orders.(2)

Outcome Measures

The primary outcome measure was the prevalence of unscheduled radiologic examination orders among all orders placed pre- and post-SCORE. Secondly, we assessed patient-related factors in relation to order resolution. Thirdly, we assessed the distribution of order resolution statuses. In addition to performed, scheduled, canceled, and expired, some orders are still pending (not scheduled or resolved) because the care coordinators are still working on them or they are deferred to a later time frame. For example, a lung nodule identified on June 1, 2019 might generate a follow-up order for chest CT for 12 months later that was initially scheduled but the patient deferred the next day. This would remain in Pending status until May 1, 2020. Lastly, we measured the proportion of orders that remained clinically necessary for each order resolution status. Finally, we evaluated the framework for classifying radiologic orders by measuring inter-annotator agreement.(12)

Statistical Analysis

The prevalence of unscheduled orders was calculated as a percentage. The chi-square test for proportion was used to assess difference in prevalence of unscheduled orders pre- and post-SCORE. Multivariable logistic regression was used to assess patient-related factors, ordering clinic specialty, and imaging modality in relation to order resolution. A p-value of 0.05 was considered statistically significant. Inter-annotator agreement for classifying radiologic orders was assessed using the kappa coefficient. All statistical analyses were conducted using R version 3.4.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Study Cohorts

After applying exclusion criteria, a total of 607,020 pre-SCORE orders and 475,000 post-SCORE orders comprised the overall study cohort. Table 1 describes the demographic characteristics among the 447 randomly selected patients whose exam orders were manually reviewed. Mean age was 55, and 87.9% of orders were for females. The most frequent modality was Mammography, accounting for 38.5% of exams ordered.

Prevalence of Unscheduled Orders

Pre-SCORE, 52,204 of 607,020 exam orders (8.6%) were unscheduled compared to 20,900 of 475,000 exam orders (4.4%) post-SCORE (χ^2, $p<0.00001$).

Order Resolution Status

Table 2 demonstrates the modes of resolution for the exam orders, and included canceled (57%), expired (21%), scheduled (1%) and performed (11%). Documented reasons for unscheduled orders included scheduling factors (e.g., order expired) and patient-related factors (e.g., patient unreachable).

Table 3 demonstrates results of the multivariable analysis of factors that were assessed in relation to order resolution. None of the factors were significantly associated with orders that were not scheduled using SCORE.

Clinically Necessary Status

Table 2 also shows the percentage of orders that remained clinically necessary by order resolution status. Canceled and expired orders were deemed clinically necessary 31.9% and 27.7% of the time. However, performed and scheduled orders were clinically necessary 98.0% and 83.3%, respectively.

Inter-annotator kappa agreement for order resolution status was 1.0 and for clinically necessary status was 0.73.

Discussion

We successfully implemented a System for Coordinating Orders for Radiology Exams at an academic medical center and significantly reduced unscheduled orders for diagnostic

imaging. The most frequent mode of resolution was order cancellation, accounting for 57% of order resolution. These orders were canceled by care coordinators primarily because they were duplicates or because patients were unreachable after three attempts. A standardized workflow enables coordinators to resolve orders in such cases with documentation in the EHR, so they do not remain pending.

Diagnostic exams improve patient care in various ways including enabling accurate explanation for patient symptoms, monitoring the effect of treatments and making earlier diagnosis of some diseases. Outpatient exams are ordered by providers for patients during a patient care visit. However, some patients may not receive the needed exams, whether due to failure to schedule the radiology appointment once the patient has left the clinic, or due to failure to ensure cancelled/no-show appointments are rescheduled. Monitoring these orders to completion can be complicated and labor-intensive. Nevertheless, addressing these unscheduled orders are essential to patient safety.

SCORE is meant to provide a “safety net” – providing a redundant system to assist care coordinators in ordering and scheduling appropriate tests. In other settings, such approaches with strategic redundancy resulted in improved process reliability by roughly one order of magnitude or one “sigma” level (e.g., improving failure rates from roughly 1 in 10 to roughly 1 in 100, from 1 in 100 to 1 in 1,000, and so on).(13) SCORE resulted in improved overall performance and reliability in resolution of unscheduled diagnostic exam orders, eliminating those which were not appropriate and expediting those that were clinically necessary.

98.0% of performed exams and 83.3% of scheduled exams were found to be clinically necessary. This is reassuring because inappropriate diagnostic imaging is a national concern given the wide variation in high-cost imaging utilization.(14, 15) In this study, only one exam order was noted to be clinically unnecessary at the time it was performed. A breast ultrasound was originally ordered for breast pain, which had resolved by the time the examination was performed. There could have been other reasons for performing the exam, but as noted previously, we did not assess the appropriateness of providers’ clinical orders; rather, we relied on the provider’s intent as documented.

It is concerning to note that for canceled and expired orders, 31.9% and 27.7% remained clinically necessary based on the documentation available in the EHR. Although we are not canceling a majority of necessary diagnostic exam orders, these pose potential safety risks. In our practice, ordering providers receive an electronic notification in their individualized ‘EHR in-basket’ for each cancelled or expired order with an opportunity to reactivate the order to mitigate such safety risks. However, erroneous cancellation or expiration of clinically necessary orders creates additional workflows for ordering providers, which may potentially lead to delays in diagnosis(16–18) or contribute to provider burnout.(19, 20) We did not evaluate whether or not the in-basket message led to clinicians reordering or otherwise reconsidering their initial order, a topic for future research.

We believe the number of unscheduled orders post SCORE in our study reflects a near steady state of clinical operations in a large academic practice rather than delays in the

delivery of care. The multivariable analysis of patient factors in relation to order resolution did not demonstrate any significant factors, such as age or insurance status, associated with unscheduled orders. However, we did not specifically assess patient preferences. For example, given abundant access to imaging devices in our community, many patients prefer to schedule their follow-up imaging exam closer to the time the exam is needed rather than immediately after the order is placed. These patient preferences contribute to a substantial number of unscheduled exams at any single point in time. Further work is needed to delineate the reasons for various patient preferences and whether or not knowledge of these factors could further decrease unscheduled exams.

Limitations

In this study, we did not address human factors that may play a role in performing diagnostic exams, including social determinants of health and other human factors.(1, 21) Majority of practices relied on the Central Model, whereas those with systematic approaches for monitoring orders stayed with the Local model. We also did not compare scheduling outcomes between those who used the Local or Central models. This study was performed at a large academic medical center and may not generalize to other institutions. In addition, we relied on provider documentation in the EHR for assessing provider's intent in determining an order's clinical necessity, as in a previous study. Thus, we did not assess appropriateness of diagnostic exam orders based on evidence.

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Take-Home Points

- A system-based approach to unscheduled diagnostic imaging orders focuses on structures and processes in order to provide patients a “safety net” to complete the diagnostic process expeditiously. This may potentially reduce errors resulting from delays in diagnostic management, thus promoting patient safety.
- A standardized workflow enables coordinators to resolve orders documented in the Electronic Health Record so they do not remain pending.
- A system-based approach significantly reduced unscheduled orders for diagnostic imaging. The most frequent mode of resolution was order cancellation, accounting for 57% of order resolution.
- 98.0% of performed exams and 83.3% of scheduled exams were found to be clinically necessary. This is reassuring because inappropriate diagnostic imaging is a national concern given the wide variation in high-cost imaging utilization.

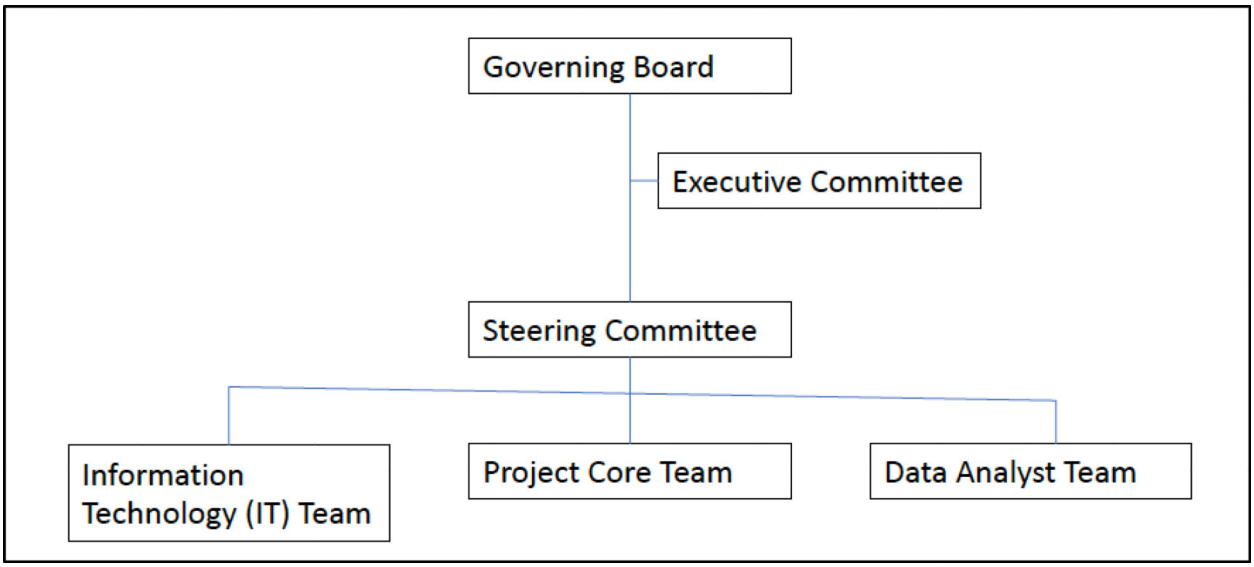

Figure 1:
System for Coordinating Orders for Radiology Exams Organizational Chart

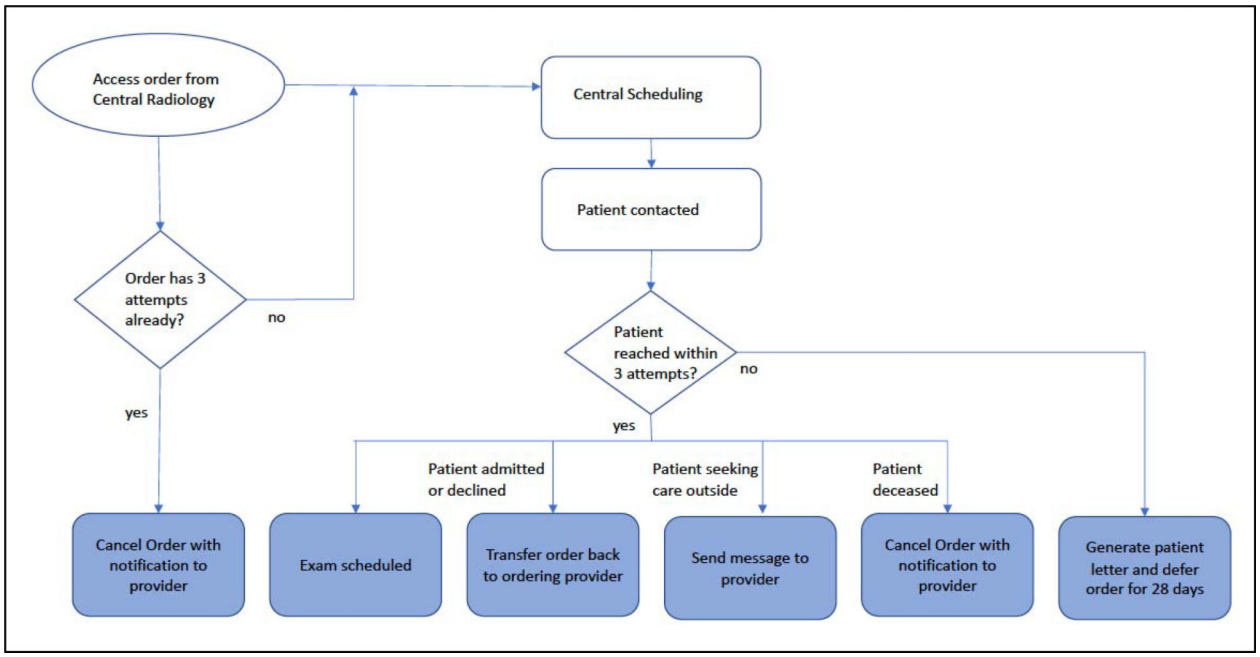

Figure 2:
Central Model Scheduling Workflow

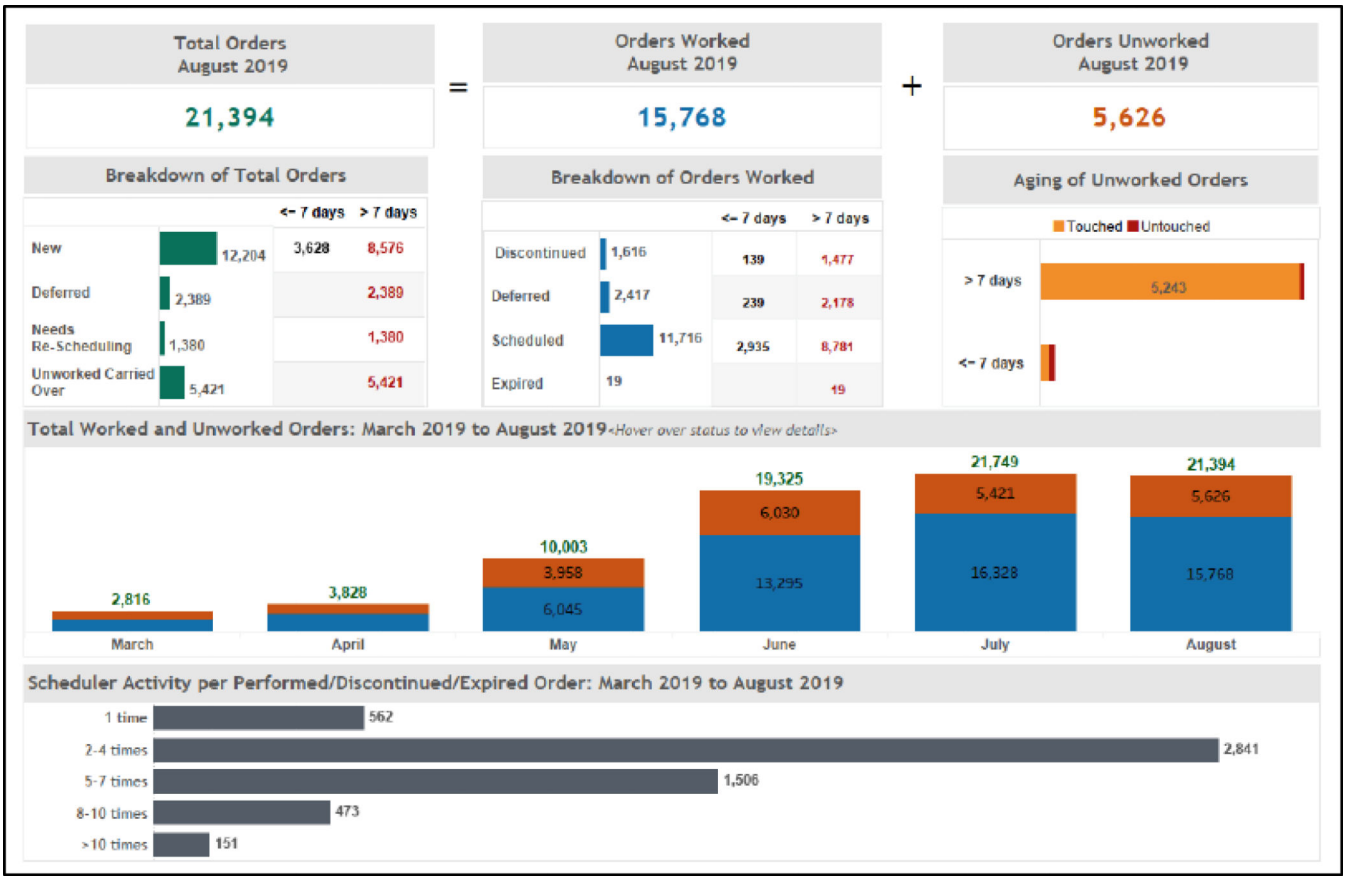

Figure 3:
Central Scheduling Dashboard

Table 1:

Patient demographics, ordering clinic specialty and imaging modality, N=447

Description	N (%)
Age in years (Range, Standard Deviation)	Mean=55 (12–99, 16.0)
Sex	
Male	54 (12.1)
Female	393 (87.9)
Race	
White	315 (70.5)
African American	43 (9.6)
Asian	26 (5.8)
Other	63 (14.1)
Ethnicity	
Hispanic	40 (8.9)
Non-Hispanic	407 (91.1)
Insurance status	
Private/Others	295 (66.0)
Public	152 (34.0)
Ordering clinic specialty	
Medicine	266 (59.5)
Other specialties	181 (40.5)
Diagnostic orders by modality	
CT	56 (12.5)
DEXA	23 (5.1)
Mammography	172 (38.5)
MRI	75 (16.8)
Ultrasound	121 (27.1)

CT: Computed Tomography, DEXA: Bone densitometry, MRI: Magnetic Resonance Imaging

Table 2:

Order status and clinical necessity of diagnostic imaging orders

Order status	Clinically necessary (%)	Clinically unnecessary (%)	N = 447 (%)
Resolved			
Canceled	81 (31.9)	173 (68.1)	254 (56.8)
Expired	26 (27.7)	68 (72.3)	94 (21.0)
Performed	50 (98.0)	1 (2.0)	51 (11.4)
Scheduled	5 (83.3)	1 (16.7)	6 (1.3)
Not Resolved			
Pending	16 (38.1)	26 (61.9)	42 (9.4)
Total	178 (39.8)	269 (60.2)	

Table 3:

Multivariable analysis of factors in relation to order resolution

Factors	Odds Ratio	95% Confidence Interval		p-value
Age in years	1.02	0.99	1.04	0.16
Sex				
Male	Reference			
Female	1.87	0.68	5.14	0.22
Race				
White	Reference			
African American	1.66	0.45	6.11	0.44
Asian	2.40	0.30	18.92	0.41
Other	0.89	0.28	2.86	0.85
Ethnicity				
Hispanic	Reference			
Non-Hispanic	1.03	0.25	4.22	0.96
Insurance status				
Private/Others	Reference			
Public	0.62	0.29	1.30	0.20
Ordering clinic specialty				
Medicine	Reference			
Other specialties	0.65	0.30	1.40	0.27
Diagnostic orders by modality				
CT	Reference			
DEXA	0.61	0.10	3.74	0.60
Mammography	0.54	0.16	1.85	0.33
MRI	0.63	0.20	2.00	0.43
Ultrasound	1.04	0.29	3.75	0.95

CT: Computed Tomography, DEXA: Bone densitometry, MRI: Magnetic Resonance Imaging