Special Review

Clinical Decision Support: Impact on Appropriate Imaging Utilization

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INTRODUCTION

The modern era has seen significant growth in the use of advanced imaging. During the early 2000s, use of advanced imaging in the United States rose to historic highs (1–4). For example, imaging expenditure per Medicare beneficiary increased 85%, outstripping a 34% relative growth in fees for evaluation and management between 2000 and 2009. Factors contributing to the increased use of imaging include advances in technology, expanded clinical indications, an aging population, and increased availability.

Advanced imaging growth subsequently declined and then leveled off during the late 2000s and 2010s during a period when imaging and the associated cost was targeted nationally for curtailment (2). The slowdown coincided with the enacted effects from the Deficit Reduction Act passed in 2005, which bundled payment and reduced reimbursement for high volume exams. Each 1% decline in reimbursement was estimated to slow imaging growth by 0.2 percent (5). Other national policies correlated with the reduction in imaging growth, including the use of radiology benefits managers, prior authorization requirements, increased cost sharing, and the use of radiology-focused clinical decision support systems.

Despite some reduction in imaging growth over the past decade, imaging use remains high on a per capita basis and estimates of imaging appropriateness are low (5). The majority of early studies evaluating advanced imaging appropriateness exist in the cardiology literature. Estimated inappropriate use of nuclear cardiology and coronary CT angiography was reported to be up to 18% of orders for these studies (6,7). Estimates for inappropriate use of diagnostic CT and MRI are estimated as high as 26% (8).

Clinical decision support (CDS) for imaging has been proposed as a national strategy to curb unnecessary use and control imaging expenditures. The Association of University Radiologists Radiology Research Alliance task force on CDS aims to review the history, current state, limitations, and opportunities for CDS and effects on improving appropriateness of imaging for patients. Our hope is that review of specific examples in CDS implementation will clarify the value and challenges that await widespread CDS implementation as envisioned by full implementation of the Protecting Access to Medicare Act (PAMA) mandate.

The current task force was organized by the AUR Radiology Research Alliance and consists of six faculty from five different institutions in the United States. The distribution of rank in the group was one full professor, three associate professors and two assistant professors, all of whom have local and/or national experience in implementing and evaluating clinical decision support. Relevant references were submitted by members of the group during an investigation phase heavily relying on prior experience and MEDLINE review.

CLINICAL DECISION SUPPORT HISTORY AND LEGISLATION

Inappropriate use of imaging has long been a focus of the American College of Radiology (ACR) since the advent of Appropriateness Criteria in the 1990s. The ACR maintains and updates evidence-based guidelines for imaging use and assigns expert panels to review numerous topics (9). Recently, the ACR repository contains 221 topics with 1050 clinical variants and 2900 clinical scenarios. For example, in 2022, the guidelines on appropriate imaging for suspected pulmonary embolism were updated as well as updates on the guideline for five new clinical topics (including recommendations for imaging after breast surgery and staging and follow up imaging for esophageal cancer) and 14 other preexisting clinical topics. Appropriateness criteria are developed using guidance issued

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by the Agency for Healthcare Research and Quality (AHRQ). The methodology relies on assessing evidence from scientific studies and defers to expert consensus when scientific evidence is insufficient. The ACR assigns one of three appropriateness categories for imaging tests based on the clinical scenario. The categories are usually appropriate, may be appropriate and usually not appropriate. Evidence based guidelines (EBGs) and Appropriateness Criteria are also maintained by other national groups including the Image Wisely initiative which is a joint effort of multiple radiology organizations to raise awareness and provide education to professionals regarding the safe use of medical imaging.

In the late 2000s, Congress explored using prior authorization to curb Medicare costs associated with advanced imaging. However, evidence for the effectiveness of the practice was limited and the administrative burden was deemed significant (10). Interest waned and in 2014, Congress passed the Protecting Access to Medicare Act (PAMA) mandating the use of CDS for advanced imaging of Medicare patients in the outpatient setting. The hope is that EBG consultation will result in less inappropriate ordering, and potentially, cost savings. Health care providers are expected to document an Appropriate Use Criteria (AUC) consult via a CMS-qualified clinical decision support mechanism (qCDSM) prior to ordering advanced diagnostic imaging. An educational and operations testing period was initially established from July 1, 2018 through December 31, 2019 and subsequently extended beyond calendar year 2021. The law contains a payment penalty phase for noncompliance that was scheduled to begin January 1, 2023. To mitigate the burden on health care institutions during the COVID-19 Pandemic, the Centers for Medicare and Medicaid services (CMS) has indefinitely delayed the start of the AUC program penalty phase (11). Failure to comply once the penalty phase begins will result in withheld technical and professional Medicare fee payments for included imaging procedures.

CDS PAMA DEFINITIONS AND IMPLEMENTATION OPTIONS

The language and definitions surrounding the implementation of CDS are confusing and complicated, but necessary to understand the current state. Clinical Decision Support Mechanisms (CDSMs) are computer-based programs that provide prompts and reminders to assist health care providers in using evidence-based clinical guidelines at the point of care (12). Some of the earliest examples of CDSM were local or institutional built systems applied in the hospital environment such as the CPRS/Vista effort at the Veteran's Health Administration (13) and the Brigham Information and Communication System (14). Given the ACR AUCs are constructed with EBGs, a computer-based system connecting the ordering process with the ACR AUCs would be considered a CDSM.

In order to be PAMA compliant, a CDSM must be "qualified". The requirements for becoming qualified are beyond the scope of this review, but once approved by CMS, relevant systems are designated a qCDSM. The recommendations/information presented within a qCDSM are rubrics assembled to guide the most appropriate diagnostic imaging choice for a patient's specific clinical condition (15). The guides may be modules integrated or available through certified electronic health record (EHR) technology. qCDSM must contain AUC made by entities also qualified by CMS. These organizations are called Qualified Provider-Led Entities (*qPLE*). Commercial providers supplying qCDSM are not qPLE by default.

As of June 2022, 17 organizations are designated qPLEs by CMS, including the ACR, American College of Cardiology Foundation, and the Society for Nuclear Medicine and Molecular Imaging (15). Multiple independent health care networks have also received qPLE designation including Duke University Health System, High Value Practice Academic Alliance and Intermountain Health care among others. Provider-led entities seeking qualification must submit applications documenting adherence to evidence-based processes as specified in CMS Code of Federal Regulations.

Twenty-three qCDSMs currently exist. According to a Reaction Data survey from 2018, the four largest private vendors provided qCDSMs by market share are the National Decision Support Company NDSC (70%), Nuance (20%), medCPU (5%) and medicalis (Siemens) (2.5%). Two companies alone control 90% of the market presence (16). The largest qCDSM by market share is the product built by NDSC. NDSC was recently bought (2018) by Change Health care and their CDSM was rebranded and now marketed as CareSelect. CareSelect maintains a web portal which can also be accessed for free (15). The portal delivers Appropriate Use Criteria (AUC) published by multiple qPLEs including the American College of Radiology, the American College of Cardiology, the National Comprehensive Cancer Network, and the Society of Nuclear Medicine and Molecular Imaging. The website will generate the required data for a payable claim for all advanced imaging exams as required by PAMA (17). It should be noted that the free version of CareSelect does not integrate with EHRs and is a standalone solution. CMS maintains a list of current qCDSMs and two other products are designated as having a free tool available for AUC consultation (AIM Specialty Health ProviderPortal and Radrite) (11).

CMS regulations specify multiple exceptions when the consulting and reporting requirements are not required for advanced imaging services. These include emergency services provided to patients with emergency medical conditions, but does not appear to exempt all care provided in an emergency department. Inpatient orders billed under Medicare Part A as well as certain significant hardships for ordering providers are also listed as exceptions to the rule (18).

It should be noted that under PAMA, CMS has identified priority clinical areas that are proposed for use when tracking providers for outlier use (15). The specifics of use and tracking metrics have not been finalized. Priority clinical areas are clinical conditions, diseases and advanced imaging services identified during annual CMS rule making with input from

stakeholders. The areas are identified considering the prevalence of disease, volume and variability of imaging use and strength of evidence supporting imaging use. The current areas include the following: coronary artery disease, pulmonary embolism, headache, hip pain, low back pain, shoulder pain, cancer of the lung, and cervical neck pain.

DOES CDS IMPROVE UTILIZATION AND/OR APPROPRIATENESS?

The effectiveness of clinical decision support (CDS) has been studied in regards to impact on total imaging volume, volume of high-cost exams, volume of inappropriate or low-yield exams, and proportion of exams deemed clinically indicated or appropriate (Table 1). In general, studies showing the largest impacts on ordering pattern were in specific or targeted use cases. However, studies reviewing aggregate effect and meta-analyses generally measured no change in total volume of advanced imaging orders and small changes in appropriateness. These trends seem to be confounded in earlier studies due to coincidental code bundling and incomplete early iterations of AUC. The following paragraphs summarize a selection of evidence found most informative by the task force.

Impact of CDS on Imaging Appropriateness

In one of the earliest studies describing integration of CDS with an electronic radiology order entry system, Rosenthal et al. reported that the proportion of completed high-cost studies (MR, CT, and nuclear medicine studies) categorized as low-yield, as defined by a low appropriateness score, decreased from 6% to 2% of studies following CDS implementation (19,20).

However, the Medicare Imaging Demonstration (MID) study, a large-scale government-initiated multi-institutional study involving 140,000 imaging requests by over 5000 clinician providers among seven aggregated practices (conveners), was initiated in 2011 and examined the effects of decision support systems on advanced imaging appropriateness (5). Results were published in 2017 and concluded that little change in appropriateness of high-cost imaging occurred following CDS implementation. One of the challenges in interpreting the results of this and other studies on exam appropriateness is that a substantial proportion of imaging exam requests were unrated for appropriateness (21). That is appropriateness could not be determined because no guidelines were available for a given scenario or the clinical data could not be mapped to one of the defined scenarios for which guidelines would apply. When excluding unrated exam requests, statistically significant improvements in appropriateness were noted at all MID conveners except one.

A more recent study examined the ordering habits of providers following ACR Select implementation (23). Low-utility inpatient and ED studies, defined as those for which ACR appropriateness score was ≤ 3, were less frequently requested after feedback on exam appropriateness was given at order entry (5%, compared to 11% before). This drop in "usually inappropriate" requests was greater in magnitude for trainees, but improvement was seen for attending physicians and mid-level providers as well (23). The frequency of clinically indicated exams in this study showed a corresponding increase from 65% to 82%. In a separate study, CDS increased ACR appropriateness scores of CT and MR requests in the ED (24). Multiple studies have demonstrated CDS can increase the appropriate use of CT for pulmonary embolism evaluation (31,32).

Impact of CDS on Imaging Utilization

Regarding advanced imaging utilization volume, the MID study referenced above noted significant decreases in utilization over time at all conveners except one, but comparing this temporal decline to matched comparison sites found no statistically significant intervention effects for most of the conveners. Even for the conveners with a statistically significant CDS intervention effect, the benefit is small, on the order of 1 fewer advanced imaging study per 100 patients. Overall, early studies of CDS showed little effect on curbing imaging use.

Sistrom et al. reported mild but statistically significant decreases in the growth rate of outpatient imaging volume for MR and CT (20) when using CDS. Although MR volume increased, the quarterly compound growth rate was 1.7% after CDS compared to 2.9% before. CDS was more effective for reducing utilization of CT, which showed larger relative decreases in quarterly volume growth (0.25% after CDS compared to 3.0% before CDS) (20). The reported drop in volume for CT in this study occurred prior to the bundling of codes related to the Deficit Reduction Act of 2005.

Several smaller studies evaluating focused clinical scenarios have shown reductions in imaging utilization. In an emergency department setting, one study reported a 31% reduction in total emergent trauma cervical spine radiographs following CDS (28), with corresponding increase in the proportion of trauma cervical spine radiographs deemed clinically indicated from 77% to 99% (28). For ED evaluation of suspected nephrolithiasis, one retrospective cohort study found CDS decreased frequency of CT urogram requests from 24% to 15%, whereas utilization at a control site was unchanged for the same period (29). Using CDS to target specific commonly occurring combinations of indications and high-cost imaging exam requests, one group reported decreased utilization by 23% to 27% for lumbar spine MRI for low back pain, brain MRI for headache, and sinus CT for sinusitis (30). However, in the ACR Select study discussed in the section above, total numbers of scans ordered each month increased significantly over the 3-year study period, so any effect of CDS on overall volume of studies is likely minimal and may be overshadowed by other factors or external trends (23). The aggregate evidence seems to indicate that CDS can

TABLE 1. Selected Publications Assessing Broad Impact of CDSImplementation on High-Cost Imaging.

Reference	Modalities / Setting	Reduced Utilization of Imaging?	Improved Exam Appropriateness?
Rosenthal et al, 2006.	CT, MR, nuclear cardiology	Not specifically assessed.	Decreased frequency of 'usually inappropriate' requests (6% to 2%).
Sistrom et al, 2009.	CT, MR	Decreased growth rate of imaging utilization (more effective for CT than MR).	Not specifically assessed.
Timbie et al., 2014. Medicare Imaging Demonstration Evaluation Report for the Report to Congress	CT, MR, nuclear cardiology	Minimal if any reduction in imaging volume.	Increased appropriateness at most sites.
Moriarty et al, 2015.	CT, MR, nuclear medicine	No significant change in rate of imaging orders.	Slightly increased frequency of 'usually appropriate' scores (76% to 82%). No significant change in frequency of 'usually inappropriate' scores.
Huber et al, 2018.	CT, MR, NM/PET, US (inpatient and ER)	Not specifically assessed.	Increased frequency of 'usually appropriate' scores (65% to 82%) Decreased frequency of 'usually inappropriate' scores (11% to 5%).
Poeran et al, 2019.	CT, MR (ER)	Rate of imaging orders increased over time during the study.	Increased frequency of 'usually appropriate' scores (60% to 66%). Decreased frequency of 'usually inappropriate' scores (19% to 10%).
Doyle et al, 2019.	CT, MR, nuclear medicine, other modalities	Utilization of targeted exams (for which a more appropriate alternative is available) decreased by 6%, but the 2% decline in overall imaging utilization was not statistically significant.	Not specifically assessed.
Palen et al, 2019.	CT, MR	No significant change in rate of imaging orders.	Slightly increased frequency of 'usually appropriate' scores (77% to 80%).
Kwan, 2020.	Meta-analysis, non-radiology	Not specifically assessed.	Increased average percentage of patients receiving desired care by 6%.

decrease utilization in targeted use cases but does not curb total imaging volumes.

Limitations of CDS Studies

A follow-up study assessed how often providers in a single MID convener acted upon CDS alerts found that providers ignored 98.9% of alerts, with 1.1% of orders modified and 0.03% canceled based on the alerts (22). However, since the vast majority (94%) of alerts were 'not actionable' (e.g., the alert stated the order was not covered by guidelines or already complied with guidelines), these numbers appear to underestimate the potential impact. Even when restricting the analysis to "actionable" alerts, defined as those expected to generate an immediate cancelation or modification by the requesting provider, for the vast majority of cases, clinicians made decisions overriding the CDS recommendations, with 8% of actionable alerts resulting in order modification and 0.2% resulting in cancelation (22).

Another potential caveat in interpreting existing CDS evidence is that many published studies use a pre-post design, making it difficult to determine how much of the change in utilization is due to CDS versus external factors. One of the few randomized studies on this topic assigned over 3500 providers to either an intervention arm that received best-practice alerts at the time of order entry or a control arm consisting of providers not receiving these alerts (25). These alerts appeared when a high-cost imaging exam was ordered that received a score of less than seven on the ACR appropriateness scale and had a higher-scoring alternative exam available. When analyzing these "targeted exams", utilization decreased by 6% compared to the control arm, and this

improvement persisted throughout the 1-year study period. However, volume of total high-cost scans did not significantly decrease, in part due to the best-practice alert often suggesting alternative examinations that are also high-cost. Palen et al. randomized over 22000 MR and CT exam requests processed by the ACR Select system and found a small but statistically significant improvement in rates of exam appropriateness for advanced imaging (ACR appropriateness score $\geq$ 7) from 77% before CDS to 80% after CDS (26). However, numbers of orders per month for advanced imaging exams were unchanged. Similarly, another study of over 33000 inpatient advanced imaging exam requests found no change in overall exam request volume following CDS implementation but reported a mild increase in appropriateness frequency from 76% to 82% (27).

Measuring the benefit of CDS is challenging and quantifying the amount of direct benefit to different stakeholders can vary depending on their roles. Data suggest a benefit of CDS to payers as inappropriate imaging has been shown to be a driver of health care cost. For example, inappropriate imaging of the common conditions of uncomplicated low back pain, non-traumatic knee pain, and non-traumatic shoulder pain comprised 20% of the annual imaging cost of these three conditions in the state of Massachusetts (33). However, the direct benefit to an institution providing imaging services is more nebulous aside from costs of installation and avoiding penalties established by payers. In addition, volume is currently the dominant driver of revenue in the current fee-for-service system. CDS creates opportunity for providers and practices to deviate from the quest for more RVUs. While focusing on reducing inappropriate imaging, radiology practices can begin to measure the avoidable harms associated with excessive imaging, which may include unnecessary radiation exposure and anxiety or overtreatment of incidental findings (34).

While the existing literature offers evidence of increased appropriateness of performed exams in targeted scenarios, the data does not support that CDS substantially reduces overall imaging volume. Many studies appear difficult to interpret due to design limitations and confounding effects of variables related to population trends and other reimbursement changes.

MULTIDISCIPLINARY COLLABORATION AND R-SCAN

CDS is more than an IT initiative; it is a multispecialty clinical collaboration. Multiple user-related factors have been identified as reasons for poor CDS compliance, including lack of institution buy-in, cultural and individual resistance to change, cognitive bias, and knowledge gaps (35).

Any successful CDS program must address all of these issues and assist with the planning and management of change. Multiple studies have shown that health care providers rarely change imaging study orders even when these orders are identified as either not appropriate or less appropriate. Therefore, a greater focus and effort must be directed on user buy-in, on high-yield continuing education for practicing health care providers, as well as the education of medical students, allied-health students and physicians in post-graduate training.

In 2014, in an effort to raise awareness of appropriate imaging and CDS, the American College of Radiology (ACR) developed and launched a new initiative named R-SCAN, the Radiology Support, Communication and Alignment Network™ (www.rscan.org). The initiative provides a framework for Radiology-Clinician teams to become familiar with and adopt specific ACR Appropriateness Criteria®, CDS technology, and Choosing Wisely® recommendations. Radiologists are able to partner with referring health care providers to select the most appropriate imaging exams for their patients. The ultimate goal is to target specific high-cost and highly utilized exams in order to reduce inappropriate exams, decrease unnecessary radiation exposure and medical errors and improve the overall quality of care and patient safety (36).

Rezaii et al. studied the results from 27 institutions using the R-SCAN framework to improve imaging appropriateness for three main clinical indications (CTA for pulmonary embolism, adnexal cyst follow-up and advanced imaging for low back pain). The aggregate data showed significant reduction in inappropriate exams ordered when clinical teams partnered with imaging teams (37). These targeted efforts highlight the importance of collaboration and education for CDS success.

R-SCAN quality improvement projects focus on commonly ordered exams and include three phases: a pre-interventional analysis (baseline), educational intervention, and post-interventional analysis. The results of these targeted interventions demonstrate that CDS seems to be effective when coupled to an educational program (38). Wintermark et al. used data from the R-SCAN network and estimated significant potential savings when similar results are applied nationally to Medicare beneficiaries (39).

Providers participating in R-SCAN are currently able to review imaging utilization across many imaging modalities, clinical indications, and types of exams through the ACR's Clinical Decision Support R-SCAN Registry. In addition, the ACR provides national benchmarking data to referring clinicians, medical practices, and health care systems for comparison of their imaging utilization stats with that of their peers.

Educational Opportunities in Clinical Decision Support for Medical and Allied-Health Students, Graduate Medical Education Trainees and Health Care providers

Radiology researchers from Baylor College of Medicine investigated the use of clinical decision support to educate medical students about appropriate imaging utilization, patient safety, and cost-effective care. Willis et al. created an education simulation portal for imaging order training that integrated clinical decision support. The system was piloted with 34 volunteer medical students and surveys showed that a large majority of medical students favored CDS integration with the regular

medical school curriculum (85%) and all students perceived value in the education simulation portal. Post intervention testing demonstrated that students perform significantly better in testing categories employing Choosing Wisely/CDS topics after simulation. The authors concluded that CDS simulation has significant potential to fill curricular gaps in radiology medical student curricula (40). Following positive feedback for the single-institution pilot, a similar, enhanced case-based education portal was created in partnership with the American College of Radiology and the National Decision Support Company (NDSC) and was named Radiology-TEACHES (Technology-Enhanced Appropriateness Criteria Home for Education Simulation). The portal contains several modules with vignettes of the most commonly encountered clinical scenarios and are designed to address gaps in traditional medical education curricula with a focus in imaging appropriateness and clinical-decision support (41). Follow up analysis demonstrated that the majority of learners expressed satisfaction with the educational content provided (70%) and that the content increases perception of preparedness to appropriately select imaging studies (65%) (42).

Since inception, Radiology-TEACHES has been implemented at hundreds of medical schools, remains a learning resource for quality improvement activities, and exposes students and health care providers to CDS before using it during actual patient care. The intent is to increase the perceived value of CDS and future acceptance of CDS feedback to modify ordering behavior (38).

OPTIMIZING CDS USE AND VALUE

Optimized commercial CDS solutions share several common features. In order to be effective, CDS must be fast and integrated with the electronic medical record for immediate access and minimal disruption of user workflow (43). AUC guidance must be available early in the ordering process so providers have an opportunity to change to a more appropriate exam or cancel inappropriate orders. Customization is necessary to be able to adapt systems to local practice patterns, but custom features must balance with the ease of system deployment and upgrades. Finally, any optimized CDS must allow for easy access to data and use analysis so improvement projects can easily establish baseline metrics and drive measurable change.

A significant value proposition for CDS is using these systems to replace requirements for pre-certification. Such a shift requires partnership with payers, but may potentially reduce costs associated with the large amount of communication required for conventional pre-certification. CDS systems have also been shown to increase the probability of payment (44). eviCore is an example of a qCDSM provider which also maintains an electronic prior authorization solution (45). The benefit of combining preauthorization with CDS is that it eliminates a potential lengthy step in ordering imaging for patients and would hopefully drive compliance and adherence to AUC guidance.

Streamlining CDS workflow also may offer the benefit of reduced errors and training requirements. Graham et al. reported that separate web-based clinical decision support systems have the potential to introduce medical errors (46). This lends further support that an integrated approach is paramount. Reduced complexity also saves time and expense training users. All new systems have a learning curve and those systems that are overly complex require users to develop a new skillset, often setting a high bar for training and implementation (47).

OPPORTUNITIES FOR INNOVATION

CDS as a Mechanism to Address Gender and Racial Disparities in Imaging Use

The use of advanced imaging in US health care is not equitable. Gender and race both contribute to disparities in imaging use. Hanna et al demonstrated inequities in the use of advance imaging (MR and CT) based on the race of patients (48). Additionally, data from the North Carolina Collaborative Stroke Registry demonstrate women and non-white patients experience longer imaging delays than male white patients in time to initial brain imaging in the setting of suspected stroke (49). Although the increasing use of technology in health care has raised concerns of increasing gender and racial disparities, evidence demonstrates CDS can decrease racial and gender disparities in health care delivery. For example, Lau et al used CDS to decrease racial and gender disparities in the prescription of best-practice VTE prophylaxis (50). CDS systems have also been shown to decrease the disparity in amputation rates due to complications of diabetes mellitus between black and white patients (51). A properly designed CDS system should be able to decrease bias within a system and provide the best imaging guidance for a given situation regardless of the gender or race of the patient.

Artificial Intelligence in Clinical Decision Support

Artificial intelligence (AI) research has seen tremendous growth in radiology in recent years (52). While image analysis and detection have been in the headlines, other noninterpretive uses of AI have also emerged (53). A wealth of clinical data is present in the EMR (54), and one form of AI, natural language processing (NLP), is capable of inspecting prior radiology reports and the EMR for clinical information that can direct optimal imaging. NLP combined with CDS can also prompt clinicians to order follow-up exams for incidental findings based upon society consensus guidelines (55) and hopefully with greater fidelity and less variability (56,57).

While AI scouring the medical record to inform CDS holds great potential for continuity of care, AI solutions are useful even without existing medical records. For example, rather than selecting indications from a list, some systems now allow users to input free text exam indication and AI algorithms help match the information to established indications (58). AI algorithms can also be trained to learn common

exam order indications for individual clinicians, clinics, and/or medical specialties, potentially improving upon the default implementations in real-time (59).

AI promises a broader role in the CDS space as well by potentially contributing to the creation of AUC. ACR Appropriateness Criteria® are created in a standardized manner with large committees of experts, but are ultimately prone to bias from their human committee members. Large-scale datasets are a rich resource to be combined with AI to generate, validate, or adjust AUC (59). Large data sets and AI could overall identify gaps and inaccuracies in existing Appropriate Use Criteria (58,60).

CONCLUSION

The Protecting Access to Medicare Act of 2014 established the requirement to consult clinical decision support when ordering advanced imaging for Medicare beneficiaries in the outpatient and emergency department setting. The phasing-in of the requirements currently remains in the testing and education phase, but at some point, is expected to enter the penalty phase which will withhold claims for non-compliance. Claims for Medicare reimbursement will need to include information regarding a CDS consultation that occurred prior to ordering advanced imaging. Early investigations of the effectiveness of CDS showed limited effects on curbing utilization. More recent evidence supports the conclusion that CDS has meaningful effect on improving appropriateness scores, the effect of which is often greatest when targeting specific uses or when changes are accompanied with multidisciplinary educational campaigns. Multiple barriers exist in achieving a smooth adoption of CDS including cultural resistance in some organizations and the desire to limit additional administrative burdens. Overall, opportunities remain for improving the design and implementation of qCDSMs and the underlying AUCs.

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