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Impact of an electronic decision support rule on ESR/CRP co-ordering rates in a community health system and projected impact in the tertiary care setting and a commercially insured population☆

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ABSTRACT

Introduction: Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are common laboratory assays used as markers of inflammation. ESR suffers from higher false positive and false negative rates than CRP. To that end, the American Board of Internal Medicine's (ABIM's) Choosing Wisely campaign has recommended against ESR testing for those with undiagnosed conditions in favor of CRP testing. This study describes the impact of a computerized provider order entry (CPOE) decision support rule against ESR/CRP co-ordering within a community health system that predates the ABIM's Choosing Wisely national guidance. To demonstrate the potential impact of such a CPOE rule within other healthcare settings, ESR/CRP ordering data from a multi-site tertiary care practice and from the commercially insured population in the OptumLabs® Data Warehouse (OLDW) were analyzed and the relative reduction in ESR/CRP co-ordering achieved within the community health system was projected onto these populations.

Materials and methods: ESR and/or CRP orders from a community health system were assessed from 2012 to 2016. Co-ordering and test concordance rates between ESR and CRP were compared before and after CPOE decision support rule launch. Similarly, ESR/CRP co-ordering across three tertiary care sites from 2015 to 2016 and the OLDW from 2009 to 2013 were assessed and the co-ordering rate reduction achieved in the community health system was mathematically projected onto these populations. Estimated payer savings from the rule's effect were calculated within each population using Medicare reimbursement rates.

Results: The CPOE decision support rule realized an unadjusted 42% relative rate reduction in ESR/CRP co-ordering within the community health system yielding an annual payer savings of $15,000 with a modest increase in ESR/CRP concordance rates. Projecting a 40% relative reduction in ESR/CRP co-ordering rates from a similarly effective CPOE rule, annual payer cost reductions exceeding $100,000 within a multi-site tertiary care setting and $1,000,000 within the OLDW would be expected.

Conclusion: ESR/CRP co-ordering represents an opportunity to eliminate testing waste and reduce payer costs. A CPOE decision support rule stably reduces ESR/CRP co-ordering rates. Similar results may occur as one component of new commercially available decision support platforms.

1. Introduction

Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are two common laboratory assays used to assess a patient's inflammatory state. The observation that the rate of erythrocyte clumping and settling varies between individuals due to inflammation or pregnancy was first described by Van der Kolk in 1820; subsequently, Herman Nasse and Robin Fahraeus attributed this phenomenon to

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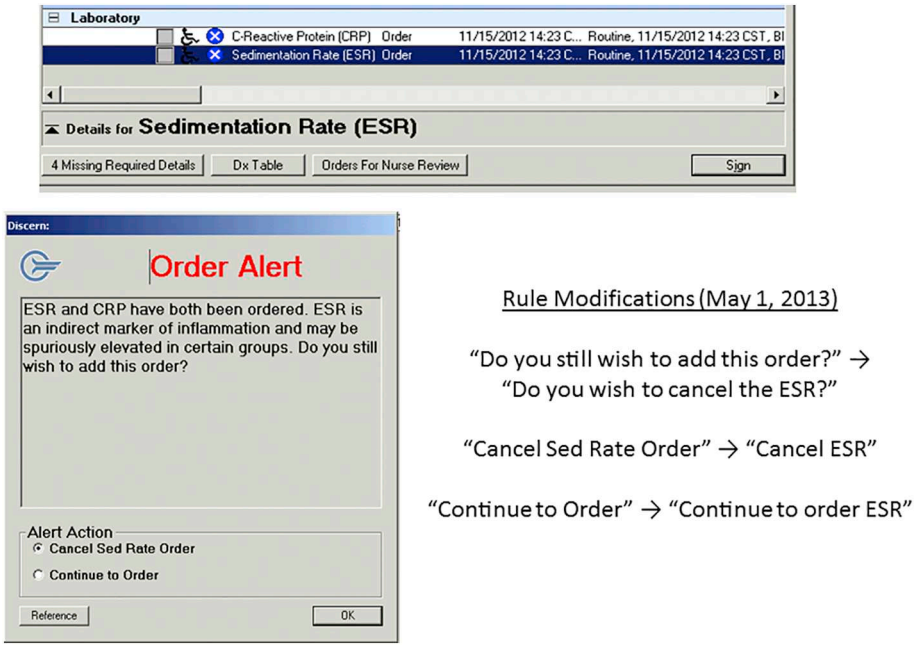

Fig. 1. Screenshots of the ESR/CRP CPOE decision support rule within the community health system's electronic medical record. Upon ordering of ESR and CRP within the same ordering session (top), an alert appears recommending cancellation of the ESR order and this cancellation option appears as the default action (bottom left). Modifications to the alert text implemented on May 1, 2013 are included (bottom right).

variations in plasma proteins [1]. Indeed, an individual's ESR depends on the balance between factors promoting sedimentation (e.g., fibrinogen, an acute phase reactant synthesized by the liver and produces erythrocyte rouleaux) and factors hindering sedimentation (e.g., repulsive negatively-charged erythrocyte membranes) [2]. ESR is therefore an indirect measure of inflammation, and increased by other non-inflammatory factors including hyperglobulinemia, hypoalbuminemia, renal insufficiency, ischemic stroke, or the use of intravenous immunoglobulins [3,4]. As fibrinogen and immunoglobulins have long serum half-lives, ESR remains elevated weeks after a triggering event resolves [4,5]. Moreover, baseline ESR is higher in females (requiring sex-specific reference ranges) and increases with age [4,6]. The standardization of ESR as a clinical test was spearheaded by Alf Westergren using a 2.5 mm vertical tube and 3.8% sodium citrate anticoagulated blood measured over a one-hour time period; this approach remains the gold standard methodology today [7]. Automated ESR methodologies for high-throughput clinical laboratories are available, but require dedicated analyzers [4,8].

CRP was discovered in 1930 by Tillet and Francis as a serum protein that reacts with the polysaccharide cell wall (fraction C) of *Streptococcus pneumoniae* [9]. Synthesized by the liver, CRP binds to the surface of bacteria or dying host cells to trigger complement activation and opsonization. CRP rises within 4–6 h of an inflammatory stimulus and has a 4–7 h half-life, allowing for rapid clearance after a source of inflammation is resolved [5]. CRP levels do not vary with sex or age and the only major factor impacting CRP kinetics is advanced liver disease, which impairs CRP synthesis (false negative CRP) [4]. CRP concentrations are measurable by common automatable chemistry analyzers already in routine use in most clinical laboratories [4,8].

Overall, co-testing of ESR and CRP reveals high concordance rates [10]. Discordant testing is most often due to elevated ESR and normal CRP; these discrepancies are largely attributable to resolving inflammatory disorders or elevated serum gamma globulins (false positive ESRs) [10]. While ESR remains in the diagnostic guidelines for some rheumatologic diseases, the known limitations of ESR have diminished its general diagnostic utility and impact on clinical decision-making when compared with CRP [11–14]. ESR testing has therefore been the target of test utilization initiatives by the American Society of Clinical Pathology (ASCP) as part of the American Board of Internal Medicine's (ABIM's) Choosing Wisely campaign, which recommends against ESR testing in favor of CRP testing for inflammation in patients with undiagnosed conditions [15].

This study describes the design, implementation, and impact of a computerized provider order entry (CPOE) decision support rule against ESR/CRP co-ordering that predates the Choosing Wisely national guidance in a community health system setting. Given that such a CPOE rule would have widespread applicability across the spectrum of the healthcare system (as indicated by the Choosing Wisely national guidance), the rule's measured impact on ESR/CRP co-ordering rates was then projected onto ESR/CRP order data from a multi-site tertiary care practice and from the commercially insured population in the OptumLabs® Data Warehouse (OLDW) to assess its potential impact within other settings.

2. Materials and methods

2.1. Setting

2.1.1. Community health system

The Mayo Clinic Health System is a community-based health care system of > 60 local physician group practices and regional hospitals within Minnesota, Wisconsin, and Iowa that at the time of this study shared a single electronic medical record system (Cerner, North Kansas City, MO, USA). An institutional audit of ESR and CRP orders from 2008 to 2009 revealed that a majority of co-ordered ESR and CRP tests were for the same medical indication and often generated concordant test results (in particular when evaluating acute inflammatory conditions) [16]. Initial audits of ESR/CRP ordering patterns revealed up to a 40% ESR/CRP co-ordering rate within parts of the institution, suggesting a significant volume of potentially redundant testing. Based on these findings, a CPOE decision support rule targeting ESR/CRP co-ordering within this community health system was approved by the community health system's clinical practice committee and the enterprise central laboratory council. On December 12, 2012, the ESR/CRP CPOE decision support rule was moved to production. The rule fired whenever ESR and CRP were ordered during the same ordering session and created a pop-up alert to encourage users to order CRP testing alone (Fig. 1). The ESR/CRP decision support rule was modified on May 1, 2013 to change aspects of the alert text. As part of the change management process for this decision support rule, the rule was also updated as needed when changes were made to ESR and CRP order listings within the electronic medical record's CPOE system.

2.1.2. Tertiary care system

Mayo Clinic also includes three tertiary care campuses located within Jacksonville, Florida, Scottsdale, Arizona, and Rochester, Minnesota. These campuses include 261, 268, and 2059 bed inpatient facilities respectively, multidisciplinary outpatient facilities, and onsite clinical laboratory services. No ESR/CRP CPOE decision support rule existed during this study at any of these sites.

2.1.3. Commercially insured population in the OLDW

The OLDW includes de-identified claims data for privately insured and Medicare Advantage enrollees in a large, private, United States health plan [17]. The database contains longitudinal health information on enrollees, representing a diverse mixture of ages, ethnicities and geographical regions across the United States. The health plan provides comprehensive full insurance coverage for physician, hospital, and prescription drug services.

2.2. Data variables

2.2.1. Community health system

The community health system data consisted of all inpatient and outpatient ESR and/or CRP laboratory orders, regardless of patient insurance type, performed within the Mayo Clinic Health System from January 1, 2012 through December 31, 2016. For each laboratory order, accession number (unique identifier for each laboratory order), draw date/time, date of birth, facility, patient sex (since ESR reference ranges are sex-specific), and test result were collected.

2.2.2. Tertiary care system

The tertiary care system data consists of all inpatient and outpatient ESR and/or CRP laboratory orders, regardless of patient insurance type, performed at one of three Mayo Clinic tertiary care campuses from January 1, 2015 through December 31, 2016. For each laboratory order, accession number (unique identifier for each laboratory order), draw date/time, date of birth, facility, patient sex (since ESR reference ranges are sex-specific), and test result were collected.

2.2.3. Commercially insured population in the OLDW

The OLDW data consists of all ESR and CRP orders from 2009 through 2013. Within the OLDW, each patient has a unique identifier to connect orders placed for the same patient across different times or locations. For each ESR or CRP order, draw date/time was also collected. Date of birth, facility, patient sex, and test result were not included given the nature of the OLDW (de-identified insurance claims data repository).

2.3. Data analysis

2.3.1. Community health system

For each unique accession number, a laboratory order was defined as CRP only, ESR only, or ESR/CRP co-ordering to calculate test co-ordering rates. All orders placed between January 1, 2012 and December 11, 2012 were defined as the pre-rule cohort and between December 12, 2012 and December 31, 2016 as the post-rule cohort. Each CRP test result was classified as normal ($\leq$8 mg/L) or high ($>$ 8 mg/L) and each ESR test result as normal ($\leq$22 mm/h for men; $\leq$29 mm/h for women) or high ($>$ 22 mm/h for men; $>$ 29 mm/h for women) to determine concordance rates for ESR/CRP co-ordered tests. Descriptive statistics were used to describe co-ordering and concordance rates within each cohort. Multivariate logistic regression was used to compare co-ordering and concordance rates between cohorts adjusted for age and sex using a forward stepwise model building process starting with cohort variable (pre-rule versus post-rule). Age and sex were added to the model if either or both were a significant predictor after adjustment for other variables within the model or were a confounder for another model variable (i.e., the coefficient of a given model variable adjusted for the confounder was outside the 95% confidence interval of the unadjusted coefficient of that same model variable).

The 2016 Medicare national floor reimbursement rate for ESR (cpt 85651; $4.83) testing was used in payer savings calculations during 2016 [18]. The payer savings in 2016 garnered from the CPOE decision support rule's effect of ESR/CRP co-ordering rates was calculated using the following formula:

$$\left(\frac{(\#ESR/CRP\ co{-}ordered)}{1-(Relative\ reduction\ in\ co{-}ordering\ rate)}-(\#ESR/CRP\ co{-}ordered)\right) * (Medicare\ ESR\ reimbursement\ rate)$$

2.3.2. Tertiary care system

For each unique accession number, a laboratory order was defined as CRP only, ESR only, or ESR/CRP co-ordering to calculate test co-ordering rates. Each CRP test result was classified as normal ($\leq$8 mg/L) or high ($>$ 8 mg/L) and each ESR test result as normal ($\leq$22 mm/h for men; $\leq$29 mm/h for women) or high ($>$ 22 mm/h for men; $>$ 29 mm/h for women) to determine concordance rates for ESR/CRP co-ordered tests. Descriptive statistics were used to describe co-ordering and concordance rates.

The 2016 Medicare national floor reimbursement rate for ESR (cpt 85651; $4.83) testing was used in projected payer saving calculations during 2015–2016 [18]. Projected total payer savings from a similarly effective CPOE decision support rule as measured in the community health system was calculated using the following formula:

$$(\#ESR/CRP\ co{-}ordered) * (Relative\ reduction\ in\ co{-}ordering\ rate) * (Medicare\ ESR\ reimbursement\ rate)$$

This study was approved by Mayo Clinic's institutional review board with a waiver of informed consent.

2.3.3. Commercially insured population in the OLDW

Given the nature of de-identified claims data, ESR and CRP orders for the same individual within a 14 day interval (+/− 7 days of the index order) were considered ESR/CRP co-ordered tests, whereas 14 day intervals with only a CRP test or only a ESR test were classified as CRP only or ESR only orders respectively. Test intervals were classified by year (2009 through 2013) and estimated testing costs for each year were calculated using that year's Medicare national floor reimbursement rates for ESR (cpt 85651) and CRP (cpt 86140) testing [18]. Projected total payer savings from a similarly effective CPOE decision support rule as measured in the community health system was calculated for each year using the following formula:

$$(\#ESR/CRP\ co{-}ordered) * (Relative\ reduction\ in\ co{-}ordering\ rate) * (Medicare\ ESR\ reimbursement\ rate)$$

Projected payer savings per member per month (PMPM) was calculated using the following formula:

$$\frac{Projected\ total\ payer\ savings}{(Overall\ OLDW\ Population * 12)}$$

3. Results

3.1. Community health system setting: ordering patterns and CPOE rule impact

Between 2011 and 2016, 130,000 orders for ESR and/or CRP were placed across 84 different collection sites (Fig. 2). Overall, the median patient age was 59.0 years (interquartile range = 40.1–74.1 years) and 58% of orders were for female patients. Similar median patient ages and female percentages were present within the pre-rule and post-rule

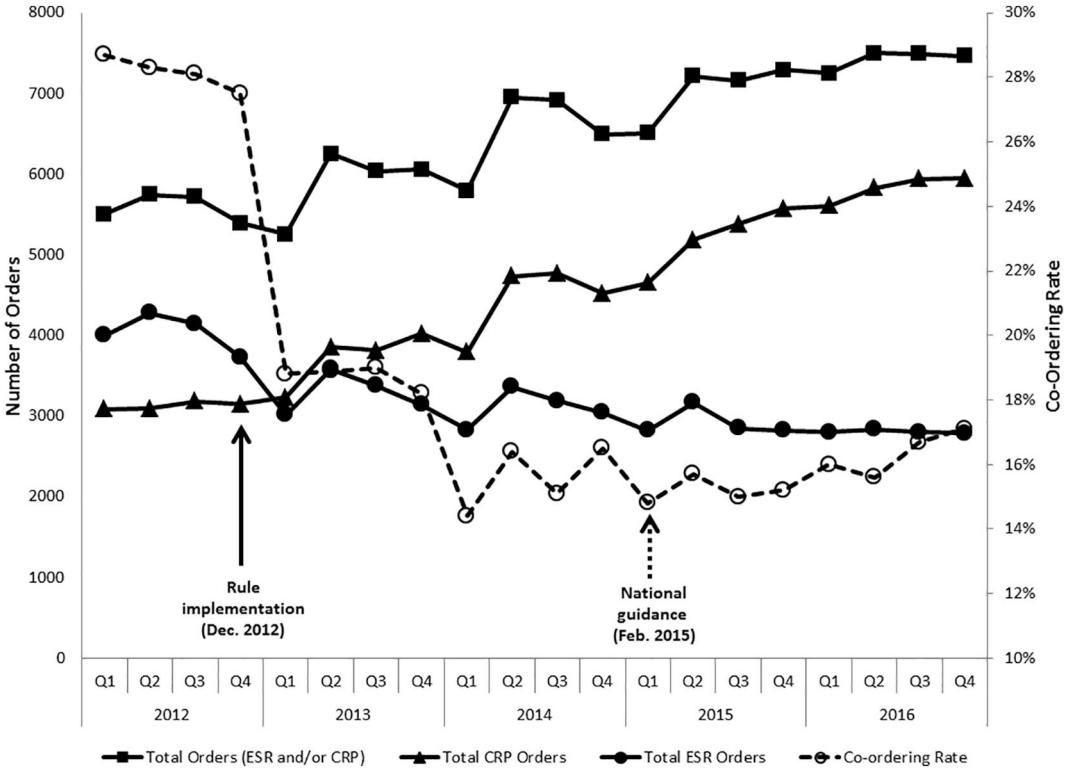

Fig. 2. Community health system ESR and CRP order volumes and ESR/CRP co-ordering rates by quarter for 2012–2016. The launching of the CPOE decision support rule occurred on December 12, 2012. The issuance of the ASCP/ABIM Choosing Wisely national guidance against ESR testing on February 3, 2015 is also indicated.

cohorts (59.1 versus 58.9 years and 60% versus 58% respectively).

Prior to implementation of the CPOE decision support rule in December 2012, ESR/CRP co-ordering rates were 28.5%. After implementation in December 2012, co-ordering rates dropped overall to 16.4% representing an unadjusted 42% relative rate reduction. The post rule reduction in co-ordering rates plateaued in the year after implementation, but then further reductions were seen starting in 2014. From 2014 to 2016, ESR/CRP co-ordering rates remained essentially stable, although overall ESR and CRP orders increased 13% during that period.

Over the complete study period, there was a 50% reduction in ESR/CRP co-ordering rates (odds ratio 0.493; 95% confidence interval (95% CI) = 0.476–0.510; $p < .0001$) after adjustment for patient sex (male versus female odds ratio 0.945; 95% CI = 0.918–0.972; $p = .0001$) and age (odds ratio per year 0.996; 95% CI = 0.996–0.997; $p < .0001$). In 2016 alone, the CPOE rule (using a conservative 40% relative reduction rate in ESR/CRP co-ordering) is estimated to have prevented 3236 additional ESR tests (payer savings of $15,630).

ESR/CRP concordance rates rose slightly, from 73.5% to 75.0%, after implementation of the CPOE decision support rule (Fig. 3). This increase in ESR/CRP concordance rates was statistically significant (odds ratio 1.10; 95% CI = 1.03–1.18; $p = .004$) after adjustment for patient age (odds ratio per year 1.009; 95% CI = 1.008–1.010; $p < .0001$). Patient sex had no significant direct or confounding effect on ESR/CRP concordance rates. Overall, the majority (58%) of discordant cases were due to an elevated ESR and normal CRP (Fig. 3).

3.2. Tertiary care center setting: ordering patterns and projected CPOE rule impact

From 2015 through 2016, ~32,000, ~35,000, and ~139,000 ESR and/or CRP orders were placed at the Florida, Arizona, and Minnesota sites respectively (Fig. 4). ESR/CRP co-ordering rates were 63%, 48%, and 51% at the Florida, Arizona, and Minnesota respectively. ESR/CRP concordance rates were similar across the three sites (80%) despite differences in co-ordering rates. Unlike in the community setting, the majority of ESR/CRP discordances were due to an elevated CRP and normal ESR (75–77% of discordant cases).

A 40% relative reduction in ESR/CRP co-ordering rates (if realized across these tertiary care sites from a similarly effective CPOE decision support rule) would have translated into 43,210 fewer ESR tests, with an estimated payer savings of $208,700 over the two year period.

3.3. Commercially insured population in the OLDW: ordering patterns and projected CPOE rule impact

The commercially insured population in the OLDW consists of 17–19 million unique privately insured and Medicare Advantage enrollees each year, with 6.5% of those individuals each year undergoing an ESR and/or CRP test (Table 1). Overall, total ESR and CRP testing volumes in this population increased by 9% over the five year period (Fig. 5). ESR/CRP co-ordering rates also rose over this five year period from 29% to 37%. Using Medicare national floor reimbursement rates for each year, the combined ESR and CRP testing costs for the commercially insured population in the OLDW rose from $12.6 to $14.2 million dollars per year (Table 1).

If a 40% relative reduction in ESR/CRP co-ordering rates were realized across this commercially insured population from a similarly effective CPOE decision support rule, the projected payer savings would increase each year from $980,000 up to $1,300,000 ($0.0048 to $0.0057 PMPM).

4. Discussion

A single CPOE decision support rule reduced ESR/CRP co-ordering rates by > 40% across a large community health system (Fig. 2). This reduction, however, took several quarters to reach full effect. While there were minor revisions in the alert text in May 2013, these revisions

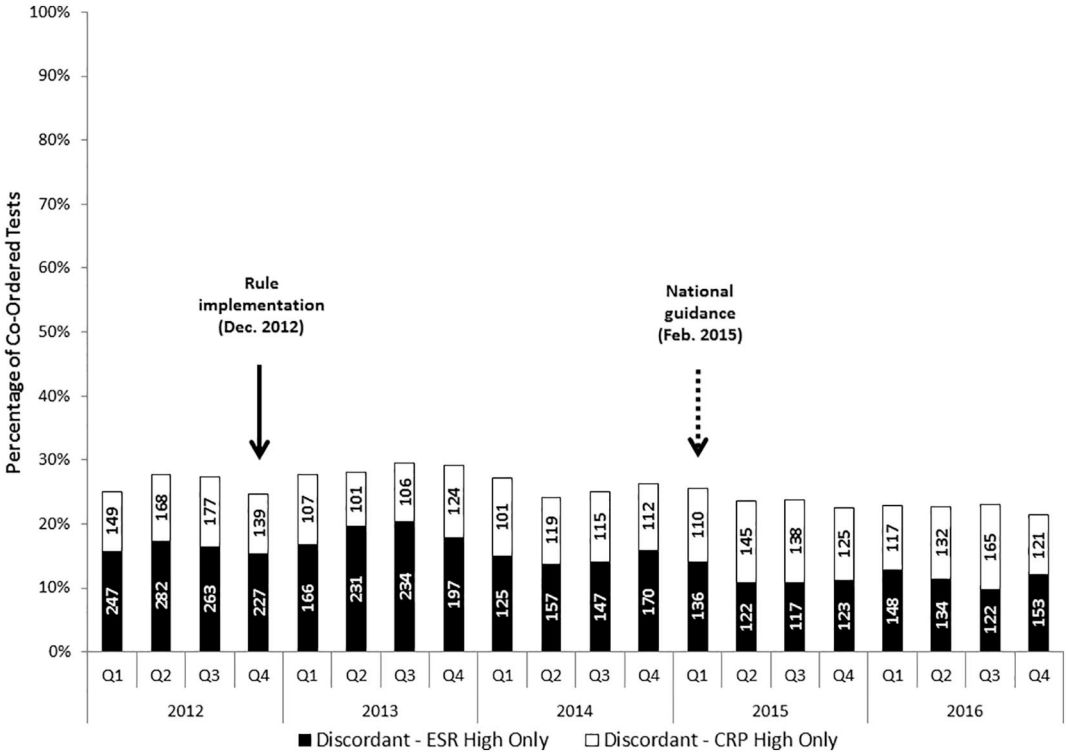

Fig. 3. Community health system discordant test volumes amongst ESR/CRP co-ordered tests by quarter for 2012–2016. The launching of the CPOE decision support rule occurred on December 12, 2012. The issuance of the ASCP/ABIM Choosing Wisely national guidance against ESR testing on February 3, 2015 is also indicated.

predated the final drop in ESR/CRP co-ordering rates by several months (Fig. 1). Plateauing of ESR/CRP co-ordering rates during the first year post-rule implementation may represent a period of adaptation to the decision support rule by the practice.

The decision support rule yielded an estimated payer savings of $15,630 across the entire community health system for 2016. Ongoing use of this decision support rule incurred minimal maintenance costs (a single text revision in May 2013; CPOE ESR and CRP test code updates

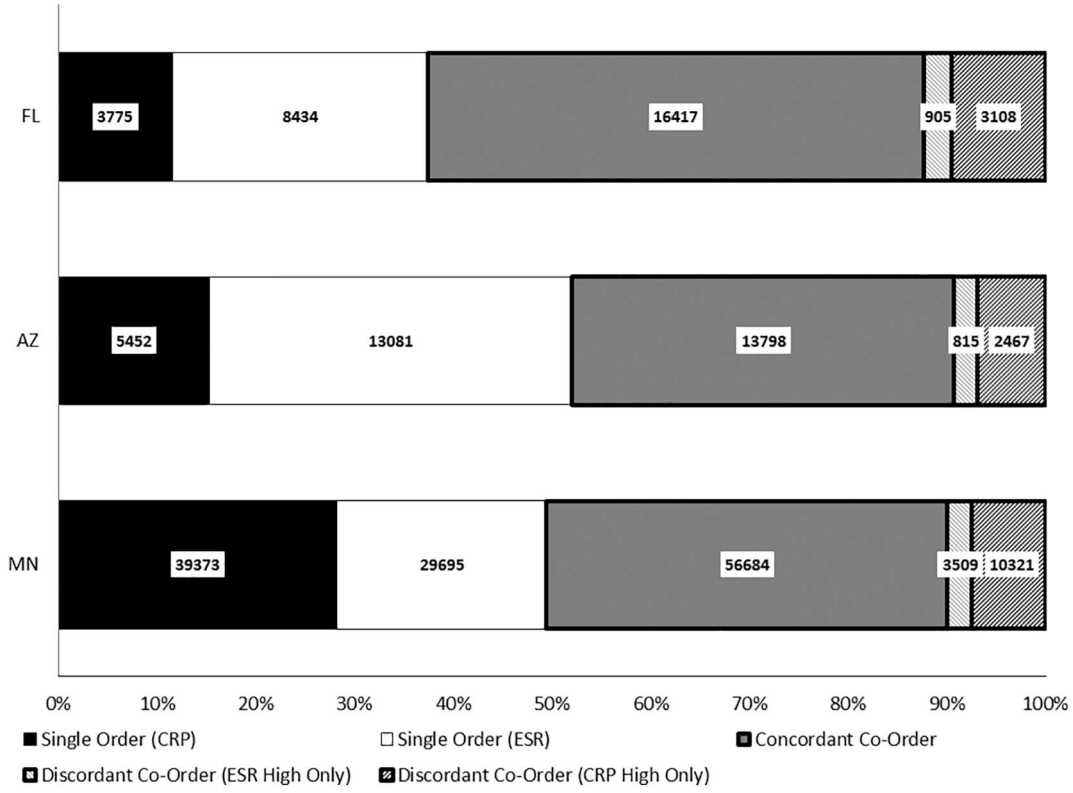

Fig. 4. Multi-site tertiary care setting ESR and CRP order numbers by site for 2015–2016. ESR/CRP co-ordered tests are indicated by a thickened border.

Table 1
Commercially insured population in the OLDW characteristics, estimated payer testing costs, and projected payer cost savings from a 40% relative reduction in ESR/CRP co-ordering rates in favor of CRP testing only.

Cohort year	Overall OLDW population	Unique individuals with CRP or ESR test	Medicare ESR fee	Medicare CRP fee	Total ESR/CRP testing payer costs	Projected total payer cost savings	Projected total savings PMPM
2009	17,154,729	1,160,094	$5.18	$7.56	$12,762,697	$982,712	$0.0048
2010	16,827,264	1,141,161	$5.08	$7.41	$12,688,332	$1,027,499	$0.0051
2011	17,883,958	1,193,445	$5.00	$7.28	$13,416,145	$1,146,238	$0.0053
2012	18,847,528	1,219,628	$5.02	$7.33	$14,214,838	$1,262,564	$0.0055
2013	19,261,389	1,223,773	$4.88	$7.11	$14,216,201	$1,315,133	$0.0057

as part of the rule's change management process). Moreover, decreasing the annual testing burden in the community health system by > 3000 ESR tests has meaningful (albeit difficult to assess) impact on laboratory workflow.

For ESR/CRP co-ordered tests in the community health system, concordance rates exceeded 70%, and a majority of discordant tests were isolated ESR elevations (Fig. 2). Similar results have been reported previously for ESR/CRP co-ordered tests in the academic tertiary care setting [10]. Discordant ESR elevations may be attributed to recently resolved inflammation (as ESR normalizes more slowly than CRP) or other factors including: paraproteinemia, hypoalbuminemia, anemia, macrocytosis, ischemic stroke, malignancy, and renal insufficiency [4,19]. Previous studies have shown that only 8% of ESR elevations in the setting of a normal CRP are due to active inflammation; thus, the vast majority of these instances represent a false positive ESR result [10]. Therefore, ESR testing in most of these clinical scenarios represents laboratory testing waste that should be curtailed through utilization management efforts.

With the introduction of the ESR/CRP CPOE decision support rule, ESR/CRP concordance rates in the community health system increased modestly (albeit significantly) suggesting that the CPOE decision support rule may have influenced the type of cases for which ordering providers chose to co-order ESR and CRP (override the CPOE decision support rule). Ideally, this CPOE decision support rule would change provider behavior in such a way that ordering providers would follow the rule (cancel ESR testing) for either cases in which ESR and CRP are likely to give concordant test results or for cases in which discordant ESR and CRP results are due to ESR's poorer diagnostic performance. In either scenario, elimination of ESR testing would reduce laboratory testing waste by eliminating redundant diagnostic testing (concordant results) or erroneous test results (false positive or false negative ESR results). Given that ESR/CRP concordance rates rose slightly after the implementation of the CPOE decision support rule, the latter scenario may have occurred but, if so, the overall effect was modest.

In the tertiary care system, ESR/CRP co-ordering rates exceeded the community setting (Fig. 3). This may reflect that patients in tertiary care settings tend to be more ill, have more difficult-to-diagnose disease processes, undergo more time-condensed clinical evaluations, or have medical trainees with less clinical experience as part of their care team. Test concordance rates in the tertiary care cohort were also higher than in the community setting, suggesting even greater testing redundancy in this setting. These ESR/CRP concordance rates align with previous data that drove initial interest in developing the CPOE decision support rule within the community health system [16]. A similarly effective

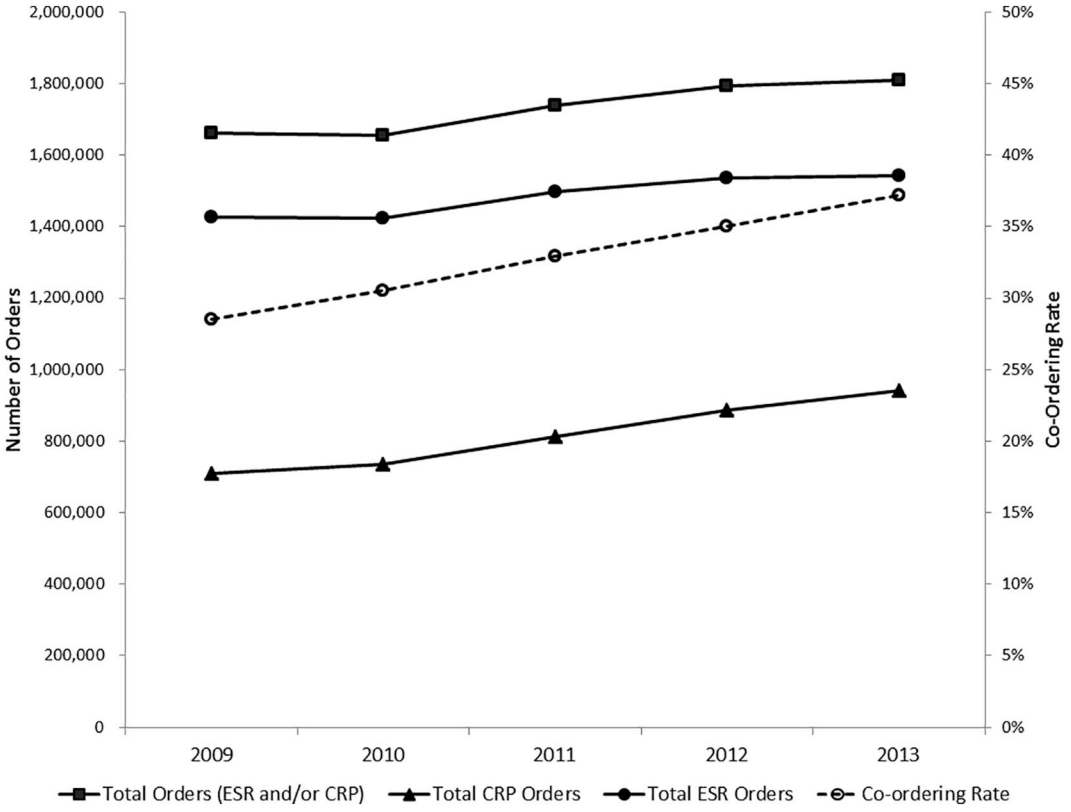

Fig. 5. Commercially insured population in the OLDW ESR and CRP order volumes and ESR/CRP co-ordering rates by year for 2009–2013.

CPOE decision support rule (40% relative reduction in ESR/CRP co-ordered tests) in this tertiary care system would have yielded > 20,000 fewer ESR tests per year, with overall annual payer savings exceeding $100,000. While these savings are modest, elimination of large volumes of ESR testing (in particular when such testing is performed manually by the Westgren method) is likely to engender additional savings and workflow benefits for the laboratory.

Across the three tertiary care campuses, the majority of discordant ESR/CRP co-ordered tests were due to isolated CRP elevations. Discordant CRP elevations have been described for several types of infection (bloodstream, pulmonary, urinary, and gastrointestinal), rheumatoid arthritis, myocardial infarction, and venothrombolic disease; conditions which may be overrepresented in the tertiary care setting [19]. Moreover, *co*-morbidities like polycythemia, disseminated intravascular coagulation, congestive heart failure, microcytosis, and NSAID or corticosteroid use can decrease ESR, thus causing a false negative ESR [4]. As a result, CRP elevations in the context of a normal ESR have been found to be nearly universally due to active inflammation in the academic tertiary care setting, and therefore represent false negative ESR results [10]. ESR testing in these clinical scenarios should be moderated (or eliminated) by utilization management efforts.

ESR/CRP co-ordering rates in the commercially insured population in the OLDW are more similar to those in the community health system setting than the tertiary care setting with annual increases in both total number of ESR and/or CRP orders and ESR/CRP co-orders (Fig. 4). Thus, even as Medicare ESR and CRP reimbursement rates declined from 2009 to 2013, estimated annual ESR and CRP payer costs rose by $1,500,000 (Table 1). Increasing ESR/CRP co-ordering rates raised the potential financial impact of a similarly effective CPOE decision support rule from $0.0048 to $0.0057 PMPM within this population.

Although these potential PMPM payer savings are modest in and of themselves, significant cost savings may be realized when multiple utilization protocols are implemented and cost savings aggregated across a number of tests. This is not an unrealistic scenario, given there are often > 5000 orderable laboratory tests available to clinicians. With the recent introduction of commercial clinical decision support platforms that incorporate the Choosing Wisely recommendations and other utilization guidelines into commercial electronic medical records, the projected cost savings described here represent only one component of the total potential savings such systems might make available to organizations [20].

This study has several limitations. The community health system results represent a single midwestern community health system utilizing a shared electronic medical record system; the CPOE decision support rule's impact on ESR/CRP co-ordering rates may vary in other settings. Unlike the community health and tertiary care systems that represent all patients regardless of insurance type, the OLDW represents only privately insured and outpatient Medicare Advantage patients and, again, the projected impact of the CPOE decision support rule in this population may vary from the estimates presented. Moreover, the OLDW does not contain laboratory orders linked by accession number. As such, the definition of ESR/CRP co-orders as ESR and CRP orders within a fourteen-day time frame may overestimate ESR/CRP co-ordering rates. Furthermore, only a minority of orders within the OLDW contains corresponding test results and, as such, robust test concordance analysis could not be performed. Finally, while Medicare reimbursement rates for ESR and CRP testing represent costs for the largest national payer of healthcare, reimbursement rates for commercial entities (such as those representing patients in the OLDW cohort) can differ significantly and thus actual payer savings will vary based on the population's payer mix.

5. Conclusions

A CPOE decision support rule had a significant lasting impact on ESR/CRP co-ordering rates in a community health system setting. If a similar rule achieved comparable ESR/CRP co-ordering reductions (40% relative rate reduction) in a multi-site tertiary care setting, potential payer savings of tens of thousands of dollars per year may be realized. Amongst the commercially insured population of the OLDW, potential payer savings of up to $0.0057 PMPM may be realized. In many clinical scenarios, ESR/CRP co-ordering represents an opportunity to eliminate testing waste and reduce payer costs with minimal patient impact.

6. Glossary

ASCP	American Society of Clinical Pathology
ABIM	American Board of Internal Medicine
CPOE	computerized provider order entry
CRP	C-reactive protein
ESR	erythrocyte sedimentation rate
OLDW	OptumLabs® Data Warehouse
PMPM	per member per month
95% CI	95% confidence interval

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Competing interests

None

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