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Interventions to reduce repetitive ordering of low-value inpatient laboratory tests: a systematic review

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ABSTRACT

Background Over-ordering of daily laboratory tests adversely affects patient care through hospital-acquired anaemia, patient discomfort, burden on front-line staff and unnecessary downstream testing. This remains a prevalent issue despite the 2013 Choosing Wisely recommendation to minimise unnecessary daily labs. We conducted a systematic review of the literature to identify interventions targeting unnecessary laboratory testing.

Methods We systematically searched MEDLINE, EMBASE, Cochrane Central and SCOPUS databases to identify interventions focused on reducing daily complete blood count, complete metabolic panel and basic metabolic panel labs. We defined interventions as 'effective' if a statistically significant reduction was attained and 'highly effective' if a reduction of ≥25% was attained.

Results The search yielded 5646 studies with 41 articles that met inclusion criteria. We grouped interventions into one or more categories: audit and feedback, cost display, education, electronic medical record (EMR) change, and policy change. Most interventions lasted less than a year and used a multipronged approach. All five strategies were effective in most studies with EMR change being the most commonly used independent strategy. EMR change and policy change were the strategies most frequently reported as effective. EMR change was the strategy most frequently reported as highly effective.

Conclusion Our analysis identified five categories of interventions targeting daily laboratory testing. All categories were effective in most studies, with EMR change being most frequently highly effective.

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WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ In 2013, Choosing Wisely recommended against performing complete blood count or basic chemistry tests in the face of clinical stability. Though many groups have attempted to follow this recommendation, existing literature is limited to small quality improvement projects and nonsystematic reviews.

WHAT THIS STUDY ADDS

⇒ Our multidatabase search yielded over 5000 studies distilled down to 41 articles which we then systematically reviewed to categorise strategies for reducing unnecessary daily laboratory testing and identify the most highly effective interventions. All approaches demonstrated effectiveness with electronic medical record changes being the most commonly used independent strategy and the strategy most frequently categorised as highly effective.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study easily allows healthcare workers to identify high value care strategies applicable to their own institutions to reduce unnecessary daily laboratory testing.

INTRODUCTION

One in every five inpatient laboratory tests ordered is unnecessary as it does not contribute to the advancement of patient care.[1] This high volume of repetitive lab testing is among the 4–5 billion tests that are performed within the USA each year, with approximately 200 billion dollars in annual healthcare spending attributed to excessive testing and treatment.[2 3] Moreover, unnecessary blood draws contribute to hospital-acquired anaemia, patient discomfort and excess downstream testing.[4 5] Drivers of inappropriate testing include defensive medicine and panel-based ordering.[1]

To help address and promote high value care, the Choosing Wisely Campaign recommended in 2013 against performing complete blood count (CBC) or basic chemistry tests 'in the face of clinical stability'.[6] Though many groups have attempted to follow this recommendation, there are limited synthesis and analysis of effective methods. One narrative review of 17 interventions suggests reduction in laboratory testing is best achieved through simultaneous interventions.[7] Our analysis builds on this review by seeking to categorise and identify the most highly effective interventions.

We performed a multidatabase systematic review to identify current methods for reducing unnecessary daily labs in the

inpatient setting and their effectiveness. This work can guide future interventions to reduce overall laboratory testing. This review focuses on interventions and outcomes specifically aimed at reducing the high volume of daily labs that do not contribute to the advancement of patient care.

METHODS

Systematic review registration

A protocol was developed and submitted to the International Prospective Register of Systematic Reviews (PROSPERO) on 10 May 2021 and registered on 10 June 2021 (registration number CRD42021254076).

Inclusion and exclusion criteria

Studies evaluating interventions that aimed to reduce daily CBCs, comprehensive metabolic panel and BMPs (basic metabolic panel) in adult inpatient departments were included. Studies that focused on other tests such as coagulation or liver function tests, as per Choosing Wisely recommendations, were excluded.[6] All studies meeting the above criteria were included irrespective of year of publication and geographic location. Full text availability in English was required. Analyses of interventions in paediatric and intensive care unit populations were excluded. Cross-sectional studies without interventions were also excluded.

Search strategy

We systematically searched MEDLINE, EMBASE, Cochrane Central and SCOPUS databases. Search terms included unnecessary lab testing, redundant labs, Choosing Wisely and high value care. Searches were performed before 14 April 2022. Search details can be seen in online supplemental file 1.

Risk of bias

To identify risk of bias within the studies, the Newcastle-Ottawa Scale for Quality Assessment for cohort studies was used, which rated studies based on representativeness, ascertainment of exposure and outcomes, and comparability of groups and duration.[8] Studies could earn a total of eight points in eight separate categories (online supplemental table 1). A score of six or higher was considered good quality, five or less was considered fair quality and two or less was poor quality and thus high risk of bias.[8] Discrepancies were resolved by discussion between two reviewers (CB and BY).

Study records

All database searches were extracted and uploaded to Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for analysis of duplicates and further data management. Four reviewers (CB, BY, JDu and JYS) participated in the initial screen of studies. Each study was reviewed by a minimum of two reviewers with discrepancies reconciled jointly by two reviewers (CB and BY). Researchers (CB, BY, JDu, JYS, MSha, WZ and HL) systematically collected data on intervention method, primary outcome of reduction in labs ordered and cost reduction. Interventions were categorised as effective if a statistically significant reduction was attained and 'highly effective' if they achieved ≥25% reduction in primary outcome. The two groups were not mutually exclusive so interventions that were 'highly effective' were also classified as effective. Data were synthesised using general descriptive statistics.

RESULTS

The systematic search yielded 5646 studies: 629 from Cochrane, 3380 from Embase, 1460 from Medline and 177 from SCOPUS, which were entered into Covidence. A total of 1384 duplicates were excluded. Of the remaining 4262 screened studies, 176 were advanced to full text screening, and ultimately 41 articles met all inclusion criteria.[9–49] Inter-rater reliability was moderate to substantial with a kappa statistic ranging from 0.40 between pairs of reviewers in the initial screening to 0.61 between final reviewers CB and BY.[50] Figure 1 demonstrates the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

The study design and characteristics of these studies, including intervention types, are shown in online supplemental table 2. Of the 41 included papers, 35 were cohort studies, 4 were non-randomised control trials (RCTs)[30 34 35 48] and 2 were RCTs.[23 32] The majority of studies were published after 2014 (31 of 41). Most interventions took place in US academic hospitals and in a single healthcare setting. Assessment of risk of bias in the studies with the Newcastle-Ottawa Scale resulted in an average score of 7.8 out of 8, with scores ranging from 6 to 8, signifying high quality of studies. An intervention was considered successful if it resulted in a statistically significant reduction in lab ordering in comparison to a control period or group.

Qualitative results

Interventions used to address laboratory overutilisation were grouped into five categories: audit and feedback, cost display, education, electronic medical record (EMR) change, and policy change. The most frequently used interventions were education (26 of 41 studies, 63.4%), followed by EMR change (19 of 41, 46.3%), audit and feedback (12 of 41, 29.3%), cost display (11 of 41, 26.8%) and policy change (10 of 41, 24.4%). Approaches included single interventions (14 of 41, 34.1%) and multiple interventions (27 of 41, 65.9%). Two of the included studies reported equivocal results in primary outcomes,[17 23] with the remainder reporting statistically significant reductions in daily labs ordered. Most studies (24 of 41, 58.5%) lasted less than 1 year.

Audit and feedback

Audit and feedback was defined as an intervention that screened provider daily lab test ordering habits and provided reflective evaluation. This strategy was effective

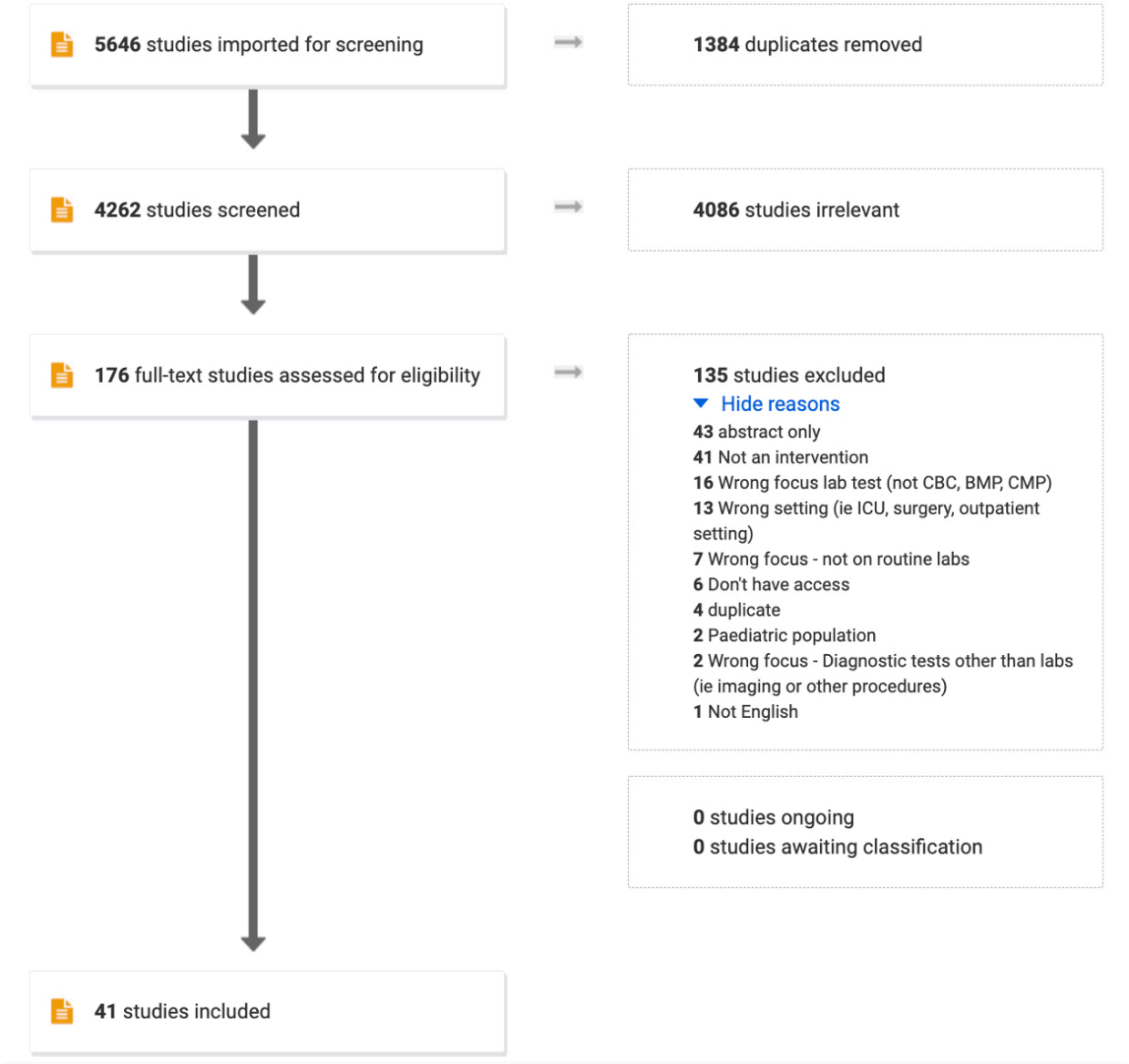

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram. BMP,basic metabolic panel; CBC, complete blood count; CMP, comprehensive metabolic panel; ICU, intensive care unit.

in 91.7% (11 of 12) and 'highly effective' in 8.3% (1 of 12) of the studies. Interventions provided feedback to frontline providers at weekly or monthly intervals. All 12 studies using audit and feedback as an intervention did so as a component of a combined intervention as opposed to an exclusive intervention. Corson *et al* incorporated audit and feedback with education via monthly emails and attributed their sustained success to a pre-existing culture of quality improvement in their facility.[27]

Cost display

Cost display interventions provided laboratory test cost data to providers at the time of ordering. It was 'highly effective' in combination with education in 30% (3 of 10) of the studies. While only a single study used this approach exclusively, 22.0% (9 of 41) included cost display as a component of a multipronged intervention. Only one study, by Hirota *et al* used cost display alone. This study took place in Japan and juxtaposed standardised cases with and without cost display, resulting in significant cost savings and a reduction in labs ordered per patient.[40] Over half of the multi-intervention studies that included cost display used cost display coupled with education (7 of 10). Sommers *et al* did not find significant cost savings and included a qualitative approach to identify mitigators of the lack of impact.[23] They found that residents reported minimal cost-awareness education as well as systemic barriers to reduction in laboratory testing, including fear and attitudes of attendings.

Education

Education was defined as any intervention that provided information to providers who ordered daily labs, excluding cost display, which was categorised separately. This intervention was effective in 42.3% (11 of 26) of studies and was highly effective in 19.2% (5 of 26) of studies. Education

was included as a component of combined interventions in 56% (23 of 41) of studies while only 7.3% (3 of 41) included this approach as their exclusive intervention. Of studies using education exclusively, 33.3% (1 of 3) were highly effective.[49] The most frequent combination was education coupled with policy change, which occurred in 34.6% (9 of 26) of included studies. Specific approaches to educational interventions varied significantly in their degree of proactivity. One study posted signs on physician computers outlining test-ordering recommendations.[45] Gupta *et al* developed lectures for residents and allotted time for resident teams to peer-review orders.[33] Meanwhile, Almeqdadi *et al* incorporated audit and feedback with biweekly discussions of repercussions of unnecessary daily labs and provided positive reinforcement incentives (such as food) for those who followed the suggested guidelines.[44] All three of these papers demonstrated successful reductions in laboratory test ordering.

EMR change

EMR change was defined as interventions that targeted reduction in lab ordering through electronic means, such as directly restricting the frequency of ordering or implementing pop-up alerts. This strategy was effective in 100% of studies (19 of 19) and highly effective in 21% (4 of 19) of studies. Most single intervention studies used EMR change (10 of 14, 71.4%). Among these single intervention studies, 30% (3 of 10) were highly effective.[13 19 20] An additional 33% (9 of 27) of the multi-intervention studies included EMR change as a component of their combined interventions. EMR change interventions were associated with success in lab test reduction but were also met with negative feedback from affected providers. One study that exclusively used an EMR change to eliminate the ability to order daily recurring tests demonstrated success in reduction of less commonly tested labs, such as coagulation studies and hepatic function panels, but did not reduce CBCs or BMPs.[29] Importantly, 43% of surveyed providers reported negative experiences with this intervention and identified an increase in workload as a result of the EMR change.[29] Procop *et al* demonstrated the use of a demanding decision support tool that was more effective in reducing the number of duplicate tests ordered compared with a less stringent counterpart.[26] However, it is important to note that the 'Hard Stop' section of this study, which entailed a stricter protocol to limit lab orders, was less favoured by many physicians and was anticipated to cause a diversion of test ordering to downstream medical staff. In this vein, EMR changes that gave providers the power to override pop-ups resulted in more favourable feedback.[19]

Policy change

Policy change was defined as any institutional modification, such as workflow change, implemented without adjusting the EMR. This strategy was effective in 100% of studies using this approach (9 of 9) and highly effective in 22% (2 of 9) of interventions. No studies exclusively used policy change, though it was incorporated in 22.0% (9 of 41) of included studies. Some examples of policy change included audit without feedback where auditors were required to use stricter guidelines in evaluating appropriateness of tests ordered and site-specific lab-ordering guidelines that required increasing provider justification for ordering labs in clinically stable patients.[22 36]

Single intervention versus multiple interventions

Most studies (27 of 41) implemented a strategy that included multiple interventions. Of the 14 studies with single intervention approaches, all were effective at reducing unnecessary daily laboratory testing. EMR change was the most common exclusive intervention approach (nine studies), followed by education (three studies) and cost display (one study).

The most common intervention combinations included education with policy change (eight studies) and education with cost display (seven studies). Combinations of audit and feedback with education were seen in nine studies while audit and feedback with education and EMR change was reported in three studies. Interventions combining education, EMR change and policy change occurred in four studies. One large-scale, multifacility study demonstrated simultaneous interventions at four different hospitals that included components of audit and feedback, EMR change, and education, with success at three of the four hospitals.[43] The unsuccessful site had the least staffing with only a single resident who rotated during the period, as well as less investment in scrutinising lab ordering in the outpatient department. Nonetheless, this multimodal intervention received significant positive feedback regarding resident involvement in changing organisational culture.[43]

Sustainability

Of the 24 studies that took place with a duration of 1 year or less, all but two demonstrated a significant change from preintervention to postintervention.[17 23] Most of the single intervention studies (8 of 14, 57.1%) had a duration of 1 year or less.[19 34 39 40 42 44 45 47]

All the studies (17 of 17) conducted over more than 1 year were successful in significantly decreasing the number of laboratory tests ordered.[18 20 21 24 25 28 29 31 33 35 37 38 41 43 46–48] The average length of these studies was 28.9 months. Eleven of the 19 studies lasting greater than 1 year used multiple interventions. The most common intervention for this group of studies was EMR change (5 of 19), followed by a combination of audit and feedback, education, and EMR change (4 of 19). Two studies demonstrated consistent and significant reduction in laboratory testing across multiple years. Konger *et al*, one of four studies with the longest duration of intervention (36 months), demonstrated significant sustainable reduction in laboratory testing across consecutive years of the study.[28] Similarly, Vidyarthi *et al* also demonstrated sustained decreases in total test volume across a 3-year interval.[25]

Randomised controlled trials

Two randomised controlled trials were included. The trial by Wertheim *et al* examined a strategy of EMR change combined with education and policy change and reported a 9% reduction in aggregate labs.[32] The authors randomised medical teams comprised of residents and attendings to either intervention or control groups. The reduction was primarily driven by decreased ordering of BMP and CBC without differential; hepatic function panel, coagulation studies and other electrolytes were not affected. Sommers *et al* investigated education and cost display through a clustered RCT of 33 teams made up of 96 residents that entailed a 45 min educational session focused on reviewing a hospital bill for one of the resident's patients.[23] They aimed at reducing patient cost burden through reduction of unnecessary lab ordering. No significant difference in lab costs between the intervention and control groups was achieved.

DISCUSSION

This systematic review identified 41 studies using five primary strategies for lab reduction: education, cost display, audit and feedback, EMR change, and policy change. All five strategies were effective in most studies. EMR change and policy change were the strategies most often reported to be effective. One-quarter of studies included were highly effective (defined as providing 25% or greater reduction in labs). When considering both sustainability and effectiveness of interventions, EMR change stood out in both dimensions. It was the strategy that was most often found to be highly effective when used as an exclusive intervention but was unfavourable among providers when strict limitations in ordering or unavoidable pop-up alerts were implemented. While other interventions such as cost display, education and policy change were similarly highly effective, they were primarily used in multifaceted interventions and less is known about their individual efficacy and sustainability. Our findings expand on previously noted trends.[7]

This systematic review adds to the prior literature review because it includes a larger number of studies, standardises components of analysis and introduces a benchmark to define the effectiveness of lab reduction across various interventions.[7] Identifying and categorising interventions into five strategies facilitates systemisation and comparison of the efficacy of such interventions, despite wide heterogeneity. This systematic review also comments on the reliability of studies including the risk of bias and unintended consequences for providers experiencing such interventions, such as dissatisfaction with overly stringent EMR changes.

Our findings suggest that institutions can develop impactful and sustainable models based on common organisational tools and mechanisms for improvement, such as EMR enhancements and hospital-based policy development. A supportive approach will be important in the implementation of any change. For example, new EMR requirements can contribute to burnout, but when done thoughtfully can provide highly effective and sustainable interventions.

This analysis has several limitations. Most importantly, only two of the identified studies were randomised controlled trials and most used pre–post analysis as opposed to a simultaneous control. One of the two randomised trials achieved a significant reduction in lab orders.[23 32] Though the low number of randomised trials precludes definitive conclusions, the non-randomised design of many of the published studies reflects the nature of most quality improvement initiatives and the consistency of results across the identified studies supports the primary conclusions. In addition, most studies were conducted within a single institution. Hospital leaders implementing EMR and policy changes across multiple sites will need to account for local differences, such as hospital culture and whether the same EMR is used. Additionally, most of the interventions lasted less than 1 year and none of the studies addressed turnover of house-staff as a factor in ordering practices, a key limitation for academic medical centres. The heterogeneous design of the studies and lack of primary data do not allow for a formal meta-analysis. Similarly, there is publication bias as interventions that were not successful were less likely to have been submitted or accepted for publication. Finally, while most studies demonstrated significantly reduced lab orders, successful interventions do not necessarily equate to reduced needle-sticks for patients, reduced cost, reduced phlebotomy labour or improved patient satisfaction.

Almost a decade has passed since the Choosing Wisely guidelines first recommended restricting daily lab ordering for clinically stable patients, yet this issue remains pervasive and challenging to address. This review identifies strategies that have the potential to reduce unnecessary laboratory testing when used alone or in combination and suggests that EMR change may be the most effective strategy.

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of the results. BY, CB, AD, MShy, MSha, AL, ST contributed to the writing of the manuscript. BY is the designated gaurantor.

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Patient consent for publication Not applicable.

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