INNOVATIONS JOURNALS

Quality Improvement Project

Managing Resource Utilization Cost of Laboratory Tests for Patients on Chemotherapy in Johns Hopkins Aramco Healthcare

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ABSTRACT

Introduction: Laboratory testing is a fundamental diagnostic and prognostic tool to ensure the quality of healthcare, treatment, and responses. This study aimed to evaluate the cost of laboratory tests performed for patients undergoing chemotherapy treatment in the oncology treatment center at Johns Hopkins Aramco Healthcare in Saudi Arabia. Additionally, we aimed to reduce the cost of unnecessary laboratory tests in a 1-year period. **Methods:** This was a quality improvement study with a quasi-experimental design using DMAIC methodology. The intervention strategy involved educating staff about adhering to the British Columbia Cancer Agency (BCCA) guidelines when ordering laboratory tests for chemotherapy patients, then integrating those guidelines into the electronic health record system. Data were collected for 200 randomly selected cases with 10 different chemotherapy protocols before and after the intervention. A paired *t* test was used to analyze differences in mean cost for all laboratory tests and unnecessary testing before and after the intervention. **Results:** A significant cost reduction was achieved for unnecessary laboratory tests (77%, $p < 0.01$) when following the BCCA guidelines. In addition, the mean cost of all laboratory tests (including necessary and unnecessary) was significantly reduced by 45.5% ($p = 0.023$). **Conclusion:** Lean thinking in clinical practice, realized by integrating a standardized laboratory test guided by BCCA guidelines into the electronic health record, significantly reduced financial costs within 1 year, thereby enhancing efficient resource utilization in the organization. This quality improvement project may serve to increase awareness of further efforts to improve resource utilization for other oncology treatment protocols.

Keywords: unnecessary laboratory tests, BCCA guidelines, lean thinking, resource utilization

INTRODUCTION

Laboratory testing is fundamental to ensuring quality healthcare. It serves as a tool for diagnosis and prognosis and as a guide for treatment decision and response. Laboratory medicine is a high-demand activity in clinical care, which requires continuous monitoring of resource utilization by scrutinizing appropriate needs.[1] Numerous studies have estimated 20–30% overutilization of organization resources and a substantial increase of unnecessary spending on healthcare institute resources due to unnecessary testing and procedures that did not contribute to improved patient care.[2,3] Understanding the value of laboratory medicine is vital for the optimal use of patient testing. Commonly, pathologists are champions of lab test utilization assessment, as they observe testing behaviors and trending patterns and can manage testing algorithms by suggesting alternatives.[4,5] Test selection is a complicated process that is sensitive to the patient and physician and is influenced by laboratory-related factors and hospital strategies.[6]

Clinical decision support systems (CDSs) have become widely recognized as important tools to ensure patient safety during healthcare decision-making. These systems are widely applied in laboratory medicine to order diagnostic and treatment monitoring tests as an integral part of the patient's electronic health record (EHR), which supports holistic patient-centered care.[7,8] Additionally,

applying evidence-based medicine in the era of EHR is highly promising, provided that it is a user-friendly system.[9,10] Research demonstrates a positive economic impact of EHR systems that incorporate CDSs on improving healthcare efficiency.[11]

Our organization follows the British Columbia Cancer Agency (BCCA) guidelines for treating oncology patients who are scheduled for chemotherapy. These guidelines cover the cancer care spectrum from prevention to diagnosis and from treatment to palliative care in accordance with established cancer management guidelines and protocols for proper care.[12] This study is a quality improvement initiative intended to improve the efficiency of resource utilization management in the oncology treatment center (OTC) at our hospital. We hypothesized that following the BCCA guidelines when ordering laboratory tests for oncology patients undergoing chemotherapy would reduce laboratory test volume and unnecessary financial strains on the healthcare system. Patient factors such as treatment outcomes and patient satisfaction were accounted for, as well as provider factors, including alignment with organization goals seeking patient safety, continuity, and sustainability.

The primary objective of this study was to reduce the cost of unnecessary laboratory tests performed for patients undergoing chemotherapy by 50% by integrating the BCCA guidelines into our EHR (Epic Systems). We assessed the impact of the intervention over a 1-year period.

METHODS

This was a single-center quality improvement project. Ethical approval was granted by the institutional review board of Johns Hopkins Aramco Healthcare in Dhahran, Saudia Arabia, and informed consent was waived. Johns Hopkins Aramco Healthcare is a 300-bed tertiary hospital located in the Eastern Province of Saudi Arabia. It offers medical care for patients, including employees and their families, with full financial coverage. The oncology institute provides care for hundreds of oncology patients per year in the ambulatory clinic.

The study design followed DMAIC methodology to accomplish the goals,[13] (DMAIC comprises the following steps: **D**efining the problem, **M**easuring the baseline, **A**nalyzing the current situation, **I**mplementing the intervention, and **C**hecking/controlling the improvement).

Defining the Problem

Until 2019, laboratory tests were ordered by oncologists or hematologists via the EHR system before the initiation of any chemotherapy cycle treatment (within 7 days). It was noticed that the same panel of lab tests was ordered for all cancers almost equally, rather than disease-specific tests per the BCCA guidelines, which is the reference for treatment protocols in the oncology institute. This leads to unnecessary laboratory tests ordered for different chemotherapy protocols that would not contribute to decision-making or improve patient outcomes.

The oncology institute can improve this practice through standardization of clinician utilization of the current BCCA guidelines for different chemotherapy protocols. These guidelines are only for patients who are going to receive treatment. This intervention is expected to improve resource utilization by reducing the cost of laboratory tests for oncology patients, including unnecessary laboratory tests, with a zero-cost action plan.

Measuring and Analyzing the Current Situation

Baseline data were collected retrospectively (January–December 2019) for 200 randomly selected oncology patients with chemotherapy treatment plans, including 10 treatment protocols. The oncology chairperson and nurse clinician, in collaboration with a quality improvement facilitator, planned to educate the staff about adhering to the BCCA guidelines when ordering the laboratory tests. The cost of laboratory tests ordered as per current practice (preintervention) versus when following the BCCA guidelines (postintervention) was compared. The laboratory tests included a complete blood count, renal panel, hepatic panel, and electrolyte panel. The 10 chemotherapy protocols included: (1) adriamycin, bleomycin, vinblastine, dacarbazine (ABVD); (2) adriamycin/cyclophosphamide (AC) taxol; (3) bortezomib; (4) avastin (bevacizumab), xeloda (capecitabine); (5) carfilzomib; (6) gemcitabine/cisplatin; (7) rituximab, cyclophosphamide, hydroxydaunorubicin hydrochloride, oncovin, prednisone (R-CHOP); (8) taxotere, carboplatin, and herceptin (TCH); (9) docetaxel; and (10) pertuzumab, trastuzumab, docetaxel (PTD). The costs for all tests were obtained from the financial department for the purpose of this study.

Implementation of Intervention

The initial phase of the intervention started in September–December 2019, which included an end-user approach and a system approach, as outlined below.

The end-user approach included educational sessions for oncologists, nurses, and clinicians to standardize adherence to the BCCA guidelines when ordering the required lab tests for each treatment protocol and explain the following benefits of evidence-based guidelines.

1. Reducing unneeded lab tests
2. Reducing wait time and invasive procedures (during blood collection)
3. Increasing patient satisfaction
4. Decreasing workload on lab staff and materials
5. Helping stat orders to be processed faster
6. Implementing an action plan with zero cost
7. Improving resource utilization management
8. Improving cost-effective use of resources

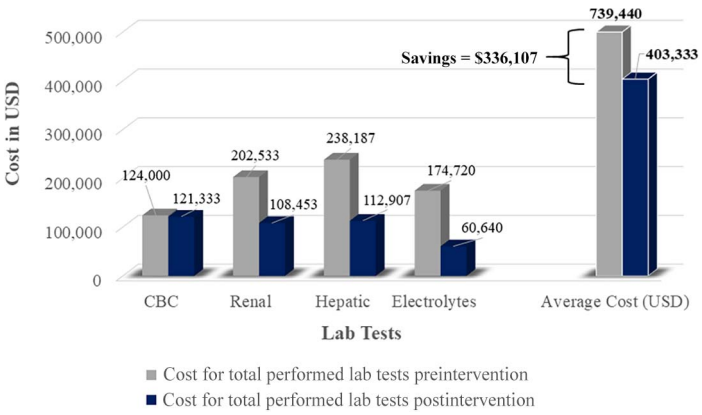

Figure 1. Mean cost of the all laboratory tests performed preintervention (without adhering to BCCA guidelines) versus postintervention (adhering to BCCA guidelines) for 200 cases with 10 chemotherapy protocols. BCCA: British Columbia Cancer Agency.

The system approach included integrating the BCCA guidelines into the EHR. All oncologists, oncology nurses, and clinicians reached initial consensus on the source of guidelines to be followed. The BCCA guidelines were then made live in Epic to alert users of the laboratory tests needed for each specific treatment protocol during order entry. This was not a strict template; it was implemented in Epic in a way to enable the ordering clinician to individualize the chemotherapy-related laboraotry tests based on the patient's condition. The final step was to monitor the changes closely throughout the study and onward to ensure that the integrated BCCA guidelines were followed as planned.

Checking/Controlling the Improvement

Postintervention data were collected from January–December 2020, including 200 randomly selected patients with cancer with matching chemotherapy protocols. Of the entire served oncology population, 20–30% were selected (it was not feasible to study the whole population) to achieve a balanced comparison of the same number of patients pre and postintervention.

Data Analysis

This study employed a quasi-experimental design (pre- and post-test). A paired sample *t* test was used to analyze the data and compare the mean cost of ordered lab tests without adhering to the BCCA guidelines (ie, preintervention data) versus the mean cost when the guidelines are followed (ie, postintervention data).

Two key performance indicators (KPIs) were used as the outcome measures. The first measure was the mean cost of all lab tests performed pre- and postintervention. The second measure was the mean cost of unnecessary lab tests performed before and after adherence to BCCA guidelines.

JASP software (version 0.14.1; Amsterdam) was used for statistical analysis.

RESULTS

Cost of All Laboratory Tests

The oncology treatment center spent approximately US $739,440 on a total of 6970 laboratory tests performed during the preintervention period (without using BCCA guidelines). The total cost was reduced to $403,333 for 4010 total tests performed for the same number of cases during the postintervention period (following BCCA guidelines). Financial savings was approximately $336,107 for 200 cases (Fig. 1). This reflects a 45.5% reduction in the total cost of all laboratory tests performed (including unnecessary tests) ($p = 0.023$) (Table 1). The difference in total mean cost for laboratory tests performed for the 200 cases after the intervention was $84,026.75 (95% CI, $16,265.86–$151,787.64).

Cost of Unnecessary Laboratory Tests

Although the BCCA guidelines were integrated into the EHR system and required educational sessions were executed for oncology staff involved in lab test ordering, extra laboratory tests were still ordered at the clinician's discretion for some cases. Approximately $434,867 was spent on unnecessary laboratory tests for cases performed during the preintervention period. This result was calculated by subtracting the cost of necessary laboratory tests (per BCCA guidelines) from the cost of all tests performed. In comparison, $98,400 was spent on a similar number of unnecessary laboratory tests for comparable cases during the postintervention period. This represents a 77.4% difference, saving approximately $336,467 ($p < 0.01$) (Fig. 2).

DISCUSSION

Oncology is an important body of content knowledge with increasing complexity regarding cancer typing, staging, prediction, biomarkers, and therapy decisions. The clinical care of patients undergoing chemotherapy treatment requires baseline blood tests prior to each

Table 1. Statistical analysis of mean difference in cost of laboratory tests[a]

Study Phase	Mean Cost	SD	SE Mean	*t*	df	SE Difference	*p*
Pre-intervention	$184,860.00	$48,176.28	$24,088.14	ref	ref	ref	ref
Post-intervention	$100,833.25	$27,322.60	$13,661.30	3.0343	6	$27,692.412	0.023

[a]Includes four groups of lab tests: CBC, renal function, hepatic function, and electrolytes panel.
df: degrees of freedom.

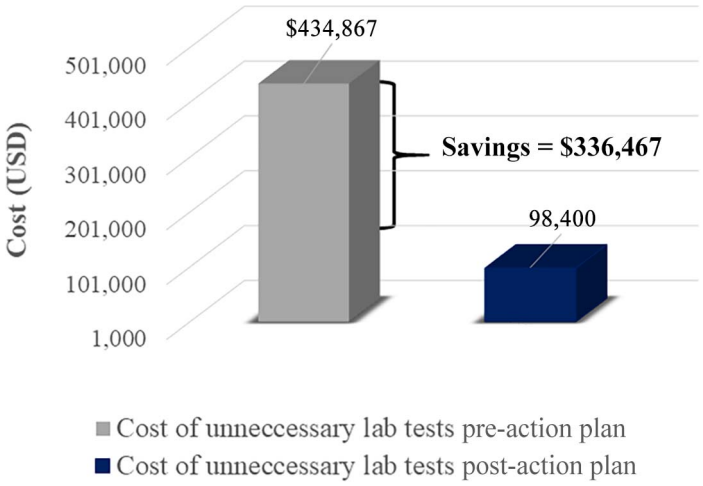

Figure 2. Mean cost of unnecessary laboratory tests performed preintervention (without adhering to BCCA guidelines) versus postintervention (adhering to BCCA guidelines) for 200 cases with 10 chemotherapy protocols.

treatment cycle for proper dosing, as the laboratory results change with disease progression.[14] Having appropriate guidelines embedded within the EHR system, including required laboratory tests for each step, are essential for proper decision making. The benefits of this approach can improve patient safety, quality of care, healthcare system efficiency, and management capability.[15,16] Physician-ordering practices for laboratory tests are considered to be the main reason for laboratory overload, requiring careful management of resource utilization.[17,18]

The Academy of Medical Royal Colleges in the United Kingdom established a guide to conserve healthcare resources and promote the value of healthcare.[19] This guide assists physicians and clinicians in effectively utilizing healthcare resources, resulting in improved quality and quantity of patient care.[19] A similar approach was implemented in our organization, where the oncologists order a list of laboratory tests to ensure the eligibility and readiness of the patient to receive their chemotherapy dose.

Medical laboratories experience high-volume activity and consume the largest portion of healthcare costs.[20] More than $6 billion (which is expected to grow), is spent on no-value-added tests or procedures annually.[21] Resource utilization measures must be implemented to prevent the catastrophic collapse of healthcare systems.[22] Clinicians face challenges in selecting proper, efficient, and safe laboratory tests to diagnose or monitor a disease, which can result in adverse clinical and financial consequences.[23] A study conducted in Saudi Arabia revealed that physicians were responsible for 10% of overutilization of laboratory tests; the authors recommended a health informatics system-based approach.[24] Laboratory tests must be ordered appropriately, guided by evidence-based practices that are built within the EHR; however, the feasibility of integrating clinical bundled guidelines, the quality of evidence on which they are based, clinician perceptions or preferences, and the potential for waste reduction are challenges that need further assessment.[25]

The current study achieved a significant cost reduction of 45.5% ($p = 0.023$) for all laboratory tests ordered according to the BCCA guidelines that were integrated within the EHR system. Patient factors including treatment outcomes as well as inconvenience, discomfort, or anxiety, were not jeopardized during this study. In addition, random interviews with patients during the study, which were not part of the planned methodology, indicated that patients were satisfied with the intervention because a smaller volume of blood was collected. This is comparable with the controlled clinical trial conducted at Johns Hopkins International of Medicine-Baltimore, which reported an 8.6% decrease in the number of laboratory tests per patient in the test group versus a 5.6% increase in the control group.[26]

Although research studies lack a comparative analysis of cost versus outcome metrics, the assimilation of EHR systems that incorporate CDSs is highly promising for cost reduction and healthcare resource utilization control.[27] The usability testing study by Press et al[28] showed that a CDS tool implemented in the emergency room resulted in efficient execution of patient care. Gong et al[29] used a similar tool along with behavioral intervention strategies to successfully reduce inappropriate antibiotic prescriptions and consequently the costs, in addition to enhancing potential clinical benefits for patients.

Low-value care in healthcare systems typically consists of unnecessary services with little or no benefit, as well as a potential for harm and over-utilization of limited resources. There are recommended evidence-based guidelines to avoid routine low-value healthcare.[30] In the current study, reducing the unnecessary (low-value) laboratory tests decreased the use of phlebotomy tools and the required blood volume, thus decreasing inconvenience, discomfort, and anxiety for patients.[31] Furthermore, all oncology physicians ($n = 7$) in our center they were admitted that the intervention alerted their behavior toward ordering only the required laboratory tests, whereas only 81% of physicians admitted the same in a study by Horn et al.[32] Occasionally, some unnecessary cost-adding laboratory tests were still ordered. However, the analysis showed that the cost of unnecessary tests was significantly reduced by 77.4% ($p < 0.01$), which successfully achieved the main goal of reducing these lab tests by at least 50%.

Successful intervention strategies with simple performance measures led to a statistically significant reduction in the cost of unnecessary laboratory tests, thereby substantially improving efficiency in healthcare resource utilization in our oncology treatment center. Quality improvement can offer an enormous financial return and increased awareness of further efforts to expand such

practices. Certainly, a positive impact may be achieved by implementing a similar intervention in other oncology treatment protocols, including immunotherapy, biological, hormonal, palliative, and radiotherapy.

There were some limitations to this study. It was not feasible to analyze the financial cost for all patients with a chemotherapy treatment protocol in our organization. A sample of 200 cases, representing 20–30% of this population, was included per the literature recommendations.[33,34] Unfortunately, we could not find another facility in Saudi Arabia or the Gulf Cooperation Council that did a similar project to compare our data with. This quality improvement project only included laboratory tests related to the chemotherapy treatments that are available in our organization. Future projects will expand this intervention to other oncology treatment protocols (ie, immunotherapy, radiotherapy biological, hormonal, and palliative therapy).

CONCLUSIONS

This quality improvement initiative in our hospital's oncology treatment center was built on the success of other healthcare organizations. This study showed that nonadherence to evidence-based BCCA guidelines leads to excessive, unnecessary utilization of laboratory tests and healthcare resources. Implementing standardized utilization of laboratory tests per BCCA guidelines into the EHR system significantly reduced financial strains on the organization.

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Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

References

1. Rubinstein M, Hirsch R, Bandyopadhyay K, et al. Effectiveness of practices to support appropriate laboratory test utilization: a laboratory medicine best practices systematic review and meta-analysis. *Am J Clin Pathol*. 2018;149:197–221.
2. Shrank WH, Rogstad TL, Parekh N. Waste in the US health care system: estimated costs and potential for savings. *JAMA*. 2019;322:1501–1509.
3. Bindraban RS, Ten Berg MJ, Naaktgeboren CA, et al. Reducing test utilization in hospital settings: a narrative review. *Ann Lab Med*. 2018;38:402–412.
4. Hallworth MJ, Epner PL, Ebert C, et al. Current evidence and future perspectives on the effective practice of patient-centered laboratory medicine. *Clin Chem*. 2015;61:589–599.
5. Huck A, Lewandrowski K. Utilization management in the clinical laboratory: an introduction and overview of the literature. *Clin Chim Acta*. 2014;427:111–117.
6. Misra S, Barth JH. How good is the evidence base for test selection in clinical guidelines? *Clin Chim Acta*. 2014; 432:27–32.
7. Plebani M, Aita A, Padoan A, Sciacovelli L. Decision support and patient safety. *Clin Lab Med*. 2019;39:231–244.
8. Rudolf JW, Dighe AS. Decision support tools within the electronic health record. *Clin Lab Med*. 2019;39:197–213.
9. McGinn T. Putting meaning into meaningful use: a roadmap to successful integration of evidence at the point of care. *JMIR Med Inform*. 2016;4:e16.
10. Levick DL, Stern G, Meyerhoefer CD, et al. Reducing unnecessary testing in a CPOE system through implementation of a targeted CDS intervention. *BMC Med Inform Decis Mak*. 2013;13:43.
11. Lewkowicz D, Wohlbrandt A, Boettinger E. Economic impact of clinical decision support interventions based on electronic health records. *BMC Health Serv Res*. 2020;20:871.
12. British Columbia Cancer Agency (BCCA). Chemotherapy protocols. Accessed Jan 1, 2021. www.bccancer.bc.ca/health-professionals/clinical-resources/chemotherapy-protocols
13. Monday LM. Define, measure, analyze, improve, control (DMAIC) methodology as a roadmap in quality improvement. *Glob J Qual Saf Healthc*. 2022;5:44–46.
14. Warr J, Hird AE, DeAngelis C, et al. Baseline blood work before initiation of chemotherapy: what is safe in the real world? *J Oncol Pract*. 2013;9:e182–e185.
15. Patt D, Stella P, Bosserman L. Clinical challenges and opportunities with current electronic health records: practicing oncologists' perspective. *J Oncol Pract*. 2018;14:577–579.
16. Johnson HM, Geisel LE, Weil A, et al. Enhancing the electronic health record to improve the quality of breast cancer care in Eastern North Carolina. *J Clin Path*. 2020;6:62–67.
17. Kwok J, Jones B. Unnecessary repeat requesting of tests: an audit in a government hospital immunology laboratory. *J Clin Path*. 2005;58:457–462.
18. Smellie WS. Demand management and test request rationalization. *Ann Clin Biochem*. 2012;49:323–336.
19. Maughan D, Ansell J. *Protecting Resources, Promoting Value: A Doctor's Guide to Cutting Waste in Clinical Care*. Academy of Medical Royal Colleges, Centre for Sustainable Healthcare; Nov 2014.
20. Vegting IL, van Beneden M, Kramer MH, et al. How to save costs by reducing unnecessary testing: lean thinking in clinical practice. *Eur J Intern Med*. 2012;23:70–75.
21. Freedman DB. Towards better test utilization - strategies to improve physician ordering and their impact on patient outcomes. *EJIFCC*. 2015;26:15–30.
22. Holladay EB. Test right critical values. *Critical Values*. 2012;5:3.
23. Laposata M. Putting the patient first–using the expertise of laboratory professionals to produce rapid and accurate diagnoses. *Lab Med*. 2014;45:4–5.
24. Khalifa M, Khalid P. Reducing unnecessary laboratory testing using health informatics applications: a case

study on a tertiary care hospital. *Proc Comp Sci*. 2014; 37:253–260.
25. McGinn TG, Guyatt GH, Wyer PC, et al. Users' guides to the medical literature: XXII: how to use articles about clinical decision rules. Evidence-Based Medicine Working Group. *JAMA*. 2000;284:79–84.
26. Feldman LS, Shihab HM, Thiemann D, et al. Impact of providing fee data on laboratory test ordering: a controlled clinical trial. *JAMA Intern Med*. 2013;173:903–908.
27. Ambinder EP. Electronic health records. *J Oncol Pract*. 2005;1:57–63.
28. Press A, McCullagh L, Khan S, et al. Usability testing of a complex clinical decision support tool in the emergency department: lessons learned. *JMIR Hum Factors*. 2015;2:e14.
29. Gong CL, Zangwill KM, Hay JW, Meeker D, Doctor JN. Behavioral economics interventions to improve outpatient antibiotic prescribing for acute respiratory infections: a cost-effectiveness analysis. *J Genet Intern med*. 2019;34:846–854.
30. Kim DD, Do LA, Daly AT, et al. An evidence review of low-value care recommendations: inconsistency and lack of economic evidence considered. *J Gen Intern Med*. 2021;36:3448–3455.
31. Harb R, Hajdasz D, Landry ML, Sussman LS. Improving laboratory test utilisation at the multihospital Yale New Haven Health System. *BMJ Open Qual*. 2019;8: e000689.
32. Horn DM, Koplan KE, Senese MD, et al. The impact of cost displays on primary care physician laboratory test ordering. *J Gen Intern Med*. 2014;29:708–714.
33. Sampling Chapter TJC. In *Specifications Manual for Joint Commission National Quality Measures* (v2016A). The Joint Commission, 2016.
34. Serdar CC, Cihan M, Yücel D, Serdar MA. Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochem Med* (*Zagreb*). 2021; 31: 010502.