DMAIC methodology to accomplish our goals. (DMAIC comprises the steps of: De ning the problem, Measure the baseline, Analyse the current situation, Implement the intervention, and Check/control the improvement).

De ning the problem

Oncology institute setting: Johns Hopkins Aramco Healthcare (JHAH) is a 300-bed tertiary hospital located in the Eastern Province of Saudi Arabia. It o ers the medical care for its bene ciaries including employees and their families with full nancial coverage. e Oncology Institute in our hospital provides care for hundreds of oncology patients per year, where the treatment is provided in the ambulatory clinic.

Previous practice: Until 2019, the laboratory tests were ordered by oncologists/haematologists through our EHR system (Epic) before the initiation of any chemotherapy cycle treatment (within 7 days). It was noticed that a panel of lab tests is almost ordered for all cancers almost equally, rather than disease-speci c tests per the BCCA guidelines, which is the reference for treatment protocols in our Oncology Institute. Obviously, there are unneeded lab tests ordered for di erent chemotherapy protocols that would not contribute to decision-making or improve patient outcomes in any way for that speci c cycle of chemotherapy, with minding patient's chemotherapy reaction and outcomes of course.

Opportunity statement: e oncology institute in our hospital can improve this practice through standardization of oncology clinician utilization of the current BCCA guidelines/recommendations for di erent chemotherapy protocols; these guidelines are only for patients who are going to receive treatment. is intervention will reduce the cost of extra unneeded lab tests, in addition to the total performed lab tests for oncology patients. Ultimately it improves utilization management with a zero cost action plan.

Measuring the baseline and analysing the current situation

Baseline data were collected, as a pilot, to investigate the status of ordering the lab tests through a cross-sectional retrospective analysis of 20 medical records for oncology patients with 10 di erent chemotherapy protocols from June to August 2019. e available chemotherapy protocols were ABVD, AC Taxol, Bortezomib, Avastin/ Xeloda, Car lzomib, Gemcitabine cis, RCHOP, TCH, Docetaxel, and PTD.

Firstly, we wanted to evaluate our adherence to the BCCA guidelines in ordering the proper lab tests for each chemotherapy protocol, according to patient health status. Secondly, to compare the number and the cost of lab tests ordered as per current practice versus the same when following the BCCA guidelines. e laboratory tests included CBC, renal panel, hepatic panel, and electrolytes panel. e prices for all lab tests were obtained from nancial department.

Quality improvement initiative goals:

1. To calculate the cost of the currently performed laboratory tests for patient undergoing chemotherapy treatments, and how they are in agreement with the BCCA guidelines.
2. To reduce the cost of "extra unnecessary lab tests" by at least 50% and the cost of the "total performed lab tests" by 40% within one-year (from January to December 2020), a er implantation of the action plan.
3. To ensure the continuity of such intervention during the second year (during 2021) and onwards to con rm the sustainability, to manage the utilization of oncology resources and reduce the costs on our organization.

Implementation of intervention

e intervention started in September to December 2019; it included an "end user approach" and a "system approach".

e end-user approach included educational sessions for oncologists, nurses, and clinicians to follow the BCCA guidelines in ordering the required lab tests for each treatment protocol, in addition to explaining the bene ts of evidence-based guidelines:

1. Reducing the extra unneeded lab tests
2. Reducing waiting time and invasive procedure (during blood collection)
3. Increasing patient satisfaction
4.

patients with matching courses of chemotherapy protocols.

Key Performance Indicators (KPIs)

KPI "Outcome measure" 1: e cost of the extra unnecessarily lab tests, de ned as the average cost of the extra unnecessarily performed lab tests a er adherence to BCCA guidelines.

KPI "Outcome measure" 2: e cost of the total performed lab tests, de ned as the average cost of the actual total performed lab tests.

Data retrieval and analysis

JASP so ware (version 0.14.1; Amsterdam, the Netherlands) was used for statistical analysis.

Results

Baseline data analysis

e baseline data analysis showed that the Oncology treatment center paid around 104,709 USD for 1085 lab tests performed for 20 patients who received 10 di erent chemotherapy protocols. However, with a simple calculation for an estimated actual cost would be around 35,085 USD for 409 lab tests when the recommended BCCA guidelines were followed. is in turn demonstrates an estimated nancial loss of 69,623 USD, which is about 33.5% higher than the actual cost, as

immunotherapy, biological, hormonal, palliative, and radiotherapy.

Conclusion

is quality improvement initiative in our hospital's Oncology treatment center is built on the success of other healthcare organizations and applied lessons learned. Non-adherence to evidence-based guidelines leads to excessive unnecessary utilization of healthcare resources. However, implementing a standardized laboratory tests recommended by BCCA guidelines into the EHR has improved e ciency, thereby reduced nancial strains on our organization.

Limitations

Unfortunately, we could not nd another facility in the kingdom or GCC that did similar project to compare our data validity with. Moreover, we decided to start our quality improvement project including only the chemotherapy protocol and the laboratory tests related to the chemotherapies available in our organization. However, the plan is to expand this intervention to the other oncology treatment protocols (i.e. immunotherapy, radiotherapy biological, hormonal, and palliative therapy).

Authors' contributions

IAJ and SAG came up with the initiative, collected the required data, participated in oncology sta education, and reviewed the analysis and the manuscript. NAF and JS provided the administrative support including integrating the clinical guidelines into the electronic health record, participated in oncology sta education, and reviewed the analysis and the manuscript. HAS formulated the quality improvement project set up and guidelines, carried the data analysis, interpretation and created the full manuscript writing.

Acknowledgments

We would like to thank Epic team for their marvellous help in incorporating the BCCG guidelines into Oncology work ow and making it user friendly.

Availability of Data and Materials

Original raw data are available with corresponding author if requested.

Ethics Approval and Consent to Participate

An approval was granted by the Ethics Committee of Institutional Review Board in our organization (November 30, 2021/IRB # 21-35). Informed consent was waived for this quality improvement initiative.

Statements and Declarations

26. Ambinder EP (2005) Electronic health records. J Oncol Prac 1: 57-63.

27. Press A, McCullagh L, Khan S, Schachter A, Pardo S, et al. (2015) Usability testing of a complex clinical decision support tool in the emergency department: Lessons learned. JMIR Hum Factors 2: e14.

28. Gong CL, Zangwill KM, Hay JW, Meeker D, Doctor JN (2019) Behavioral economics interventions to improve outpatient antibiotic prescribing for acute respiratory infections: A cost-effectiveness analysis. J Gen Intern Med 34: 846-854.

29. Harb R, Hajdasz D, Landry ML, Sussman LS (2019)