



Contents lists available at ScienceDirect

Saudi Pharmaceutical Journal

journal homepage: www.sciencedirect.com

Original article

Colorectal cancer-related resource utilization and healthcare costs in Saudi Arabia

Bander Balkhi^{a,*}, Ahmed Alghamdi^a, Saeed Alqahtani^a, Marwan Al Najjar^b, Abdullah Al Harbi^b, Thamer Bin Traiki^c^a Department of Clinical Pharmacy, College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia^b College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia^c Department of Surgery, College of Medicine, King Saud University, Riyadh 11472, Saudi Arabia

ARTICLE INFO

Keywords:

Colorectal cancer
Cost of illness
Recourse utilization
Saudi Arabia

ABSTRACT

Background: Recently, there has been an increase in the incidence of colorectal cancer in Saudi Arabia. Although numerous studies worldwide have investigated the economic burden of colorectal cancer the information specific to Saudi Arabia remains limited. While advanced cancer treatments offer substantial benefits, they they also come with substantial financial challenges.

Objective: This study aimed to estimate the economic burden of colorectal cancer and identify the primary cost drivers.

Method: This retrospective, single-center cost of illness study examined all patients with colorectal cancer from January 2017 to December 2020. This study used a micro-costing, bottom-up approach to estimate healthcare resource utilization and direct medical costs associated with colorectal cancer.

Result: The study included 326 patients with colorectal cancer. The total direct medical cost for all patients were \$19 million, with an annual cost per patient of \$58,384. Medication costs were the primary driver of healthcare spending (45%) of the total cost, followed by surgical costs (27%). This study explained cost associated with colorectal cancer, which represents a significant cost to the Saudi healthcare budget. The expected growth and aging of the population and availability of costly treatments may lead to an increase in costs. These findings are valuable for healthcare policymakers seeking to comprehend the economic challenges posed by colorectal cancer.

1. Introduction

Colorectal cancer (CRC) is a significant global health concern including in Saudi Arabia. CRC is the second most common cancer in Saudi Arabia, accounting for approximately 15 % of all cancer cases. The incidence of CRC has been increasing in Saudi Arabia, with a reported increase of 74 % over the past two decades (Asiri et al., 2020). Despite significant improvements in mortality rates over the past few decades, mainly due to effective treatment for advanced cancer and early detection, CRC remains one of the leading causes of death globally.

With an aging population and improving survival rates of cancer patient in Saudi Arabia, CRC is increasingly recognized as a chronic condition requiring continuous care. The management of CRC encompasses a wide range of treatment approaches, carefully customized to

meet the individual needs of patients. Multiple treatment strategies are available for CRC, including surgery, stoma creation, chemotherapy (including biologics and chemicals), immunotherapy, radiotherapy, and targeted medications. Recently, several medications have entered the market to provide treatment options for patients with CRC (Poston et al., 2011). Technological advancements have enhanced the detection and treatment of CRC, leading to improved survival and mortality rates (Bray et al., 2012). However, the introduction of new medical technologies and expensive drugs has led to a substantial economic burden associated with CRC, putting pressure on policymakers to provide patients with the required care and efficiently utilize the limited healthcare budget (Registry, 2018, Almatroudi 2020).

A comprehensive analysis conducted by the National Institutes of Health in United States revealed that medical expenditures associated

Peer review under responsibility of King Saud University.

* Corresponding author.

E-mail address: bbalkhi@ksu.edu.sa (B. Balkhi).<https://doi.org/10.1016/j.jsps.2023.101822>

Received 9 September 2023; Accepted 9 October 2023

Available online 12 October 2023

1319-0164/© 2023 The Author(s). Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

with CRC were approximately \$14.1 billion in 2010. Projections suggested that this figure would rise to \$21 billion by 2030, primarily driven by the availability of costly medications (2018, [Registry, 2018](#), [Stukalin et al., 2022](#)). CRC ranks as the second most expensive cancer type after breast cancer. Extensive studies conducted in various countries such as the United States, Jordan, and South Korea, have estimated the overall annual cost of CRC per patient to be between \$7,259 and \$28,626 ([Byun et al., 2014](#), [Alefian et al., 2020](#), [Bhimani et al., 2022](#)). In Nordic countries, CRC is the second most financially burdensome cancer on a per-patient basis ([Malila and Hakulinen 2003](#)).

The extensive resources required for the diagnosis and treatment of CRC, such as general laboratory tests, diagnostic procedures, hospitalization, clinic visits, and emergency visits, pose a considerable economic burden on the healthcare system, patients, and their families ([Xi and Xu 2021](#)). As cancer and related costs are increasing at a fast pace, decision makers in the healthcare sector are struggling to provide patients with the latest treatments due to limited financial resources. Considering the increasing pressure on healthcare systems to provide high-quality care with scarce resources, understanding the cost burden of cancer is critical ([Jo 2014](#)).

Cost-of-illness (COI) studies provide critical information for decision makers to prioritize treatments and aid in the allocation of scarce resources within the healthcare sector. A thorough understanding of the economic burden of CRC can help inform cancer-related policies intended to provide efficient patient care. Currently, studies on the economic burden of CRC in Saudi Arabia are scarce. Hence, this study aimed to estimate the total healthcare costs from payer perspective and assess the primary cost drivers of treating patients with CRC.

2. Materials and methods

2.1. Study design and setting

This was a retrospective, single-center COI study on patients with CRC from January 2017 to December 2020. This study was conducted in King Saud University Medical City (KSUMC), Riyadh, Saudi Arabia. This tertiary hospital provides primary, secondary, and tertiary care. Moreover, this hospital acts as a referral center for the entire country. The hospital has 1200 beds and 32 operating rooms. It contains an oncology center with a capacity of 1,000–3,000 patients.

A COI model was developed to estimate the direct medical costs related to CRC from the payer's perspective. To ensure precision and accuracy, a micro-costing approach was "bottom-up" approaches employed. This approach involves the detailed analysis of individual components of healthcare resources and their associated costs. Prevalence-based studies quantify the costs incurred by all individuals due to illness within a defined period. In addition, this study predicted the overall economic burden of CRC in Saudi Arabia, considering sex,

age, and cancer type. The study cohort consisted of adult patients aged ≥ 18 years with CRC who underwent medical treatment for CRC within the timeframe of January 1, 2017, to December 31, 2020. An index date, corresponding to the date of the patient's initial CRC-related hospital visit during the study period, was recorded for each participant. Subsequently, data for each patient was collected for a one-year post index date (as illustrated in [Fig. 1](#)). The study encompassed patients referred to clinics and subsequently diagnosed with CRC. Following this initial data collection, our analysis transitioned to estimating the costs associated with colorectal cancer over the course of one year subsequent to the index date.

2.2. Patient selection

The study included all patients (≥ 18 years) with CRC who received any type of CRC medical management during the study period. Patients who were not receiving any type of medical management for CRC or who did not have a medical file were excluded.

2.3. Data source and variables

Patient medical information was obtained from the KSUMC using International Classification of Diseases 10th Revision (ICD-10) coding system to identify all patients with CRC. The data collection period extended from 2017 to 2020. The initial step involved identifying all patients with colorectal cancer (CRC) within this timeframe.

To ensure the accuracy and comprehensiveness of the data, all patient information was extracted from electronic health records (EMR). Aligned with the payer perspective adopted in our study, this study examined healthcare resource utilization and direct medical costs related to hospital visits (emergency room [ER], clinics, intensive care unit [ICU], and hospitalization), laboratory tests, diagnostic procedures, chemotherapy, radiation therapy, supportive care (immunotherapy, antibiotics, antidiarrheal, antiemetic, anti-constipation, and analgesics), and surgery.

In the process of estimating costs, we meticulously measured and quantified the healthcare resources utilized for specific interventions carried out on each patient throughout the study duration. Subsequently, we determined the costs associated with these interventions. This involved computing the overall direct cost per patient for each disease stage, which was derived by multiplying the unit cost by the corresponding quantity utilized.

Moreover, the overall economic burden of CRC in Saudi Arabia was predicted using the following steps and data sources:

1. The incidence of CRC in Saudi Arabia was obtained from the Saudi Cancer Registry. ([Registry, 2018](#))

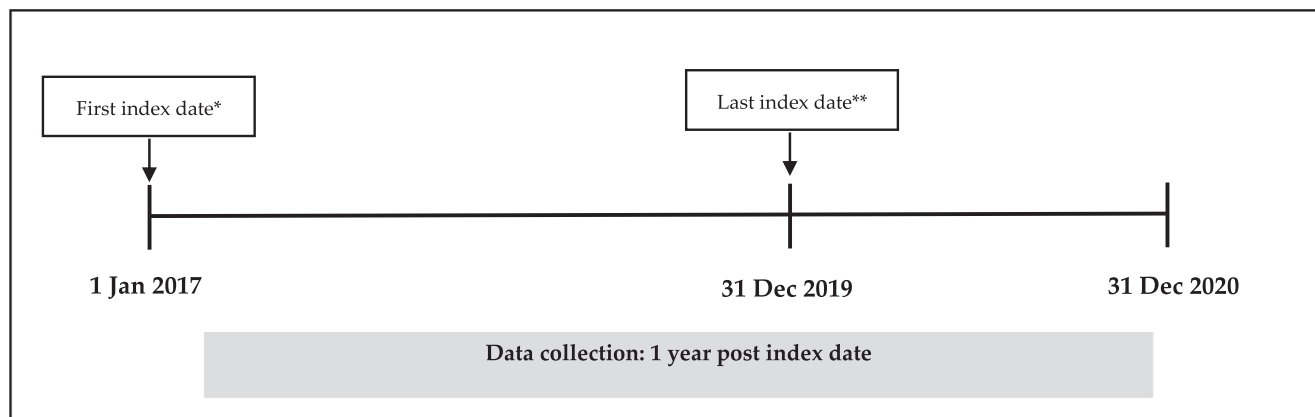


Fig. 1. Study design. * Index date were the date of first CRC visit during the study period** last date for patients to be included in the study.

- Population data for Saudi Arabia was obtained from the General Authority for Statistics.(Statistics)
- The total number of CRC cases was calculated using the prevalence rates.
- The average costs per patient for each age group, cancer type, and sex were determined.
- The number of patients with CRC was multiplied by the corresponding average cost per patient to calculate the total economic burden.
- The following formula was used to predict the overall economic burden of CRC in Saudi Arabia: direct medical costs = average medical costs per patient × estimated number of patients with CRC in Saudi Arabia (Meropol et al., 2009, Yabroff et al., 2021).

It's important to acknowledge that patients diagnosed with CRC are predominantly directed towards tertiary hospitals or specialized center. These hospitals usually adhere to standardized treatment guidelines and protocols, which contribute to a certain level of consistency in the management of CRC cases across these institutions.

2.4. Data analysis

A descriptive statistical was conducted to identify the demographic characteristics, healthcare resource utilization, and direct medical costs of patients with CRC. Data were presented as means \pm SD(standard deviations), and percentages for continuous and categorical variables. T-tests were conducted with a significance level of 0.05 to determine statistically significant differences in the variables related to healthcare resource utilization, and direct medical costs among patients with CRC.

The COI model was constructed to illustrate the management pathway of CRC and healthcare resources used. Cost data are presented as total and average costs per patient per year. To facilitate meaningful comparisons and provide a common currency for analysis, all costs are presented in United States Dollars (USD) with a conversion rate of 1 USD equaling 3.75 Saudi Riyals (SAR). This approach incorporates annual exchange rates. To standardize the cost, all costs were converted to \$ values for 2020. All data were analyzed using the Statistical Package for the Social Sciences (SPSS) V21.0 (IBM Corp., Armonk, NY, USA).

3. Results

This study enrolled 326 patients diagnosed with CRC, of which two-thirds were male. The majority of patients (89 %) were of Saudi nationality. Among the patients, 233 (71 %) were below the age of 65 years, and 93 (29 %) were above the age of 65 years. The mean age of the male patients was 59.2 years and that of the female patients was 55.27 years. The most common cancer types were colon cancer (63 %), followed by rectal cancer (24 %). CRC cases were mostly diagnosed at stage 3 (46 %), followed by stage 4 (25 %). Table 1 presents an overview of the characteristics of the study population.

The total cost of treatment was \$19 million, resulting in an average cost of \$58,384 per patient. When analyzing costs by gender, we observed that the mean cost for male patients was \$56,998.20, while for female patients, it amounted to \$60,249.38. In terms of age groups, those under 65 had a mean cost of \$59,632.31, whereas patients aged over 65 had a slightly lower mean cost of \$55,258.04. Additionally, when examining the impact of cancer type on healthcare costs, colon cancer incurred a mean cost of \$66,670.60, rectal cancer had a mean cost of \$44,602.53, and colorectal cancer had a mean cost of \$43,880.38. The overall findings from this study, encompassing all patients, demonstrated a mean cost of \$58,384.44. The highest total cost was associated with patients under the age of 65, accounting for \$13.8 million (73 % of the total cost). Moreover, the total cost of CRC was higher among males than females, with a percentage distribution of 56 % and 44 %, respectively. Table 2 shows the total cost, number of patients, and average cost.

Table 1
Characteristics of the study population.

	No. of Patients	%
Gender		
Male	187	57 %
Female	139	43 %
Age mean years (SD)	57.45(12.61)	
Age Group		
< 65	233	71 %
> 65	93	29 %
Nationality		
Saudi	293	89.8 %
Non Saudi	33	10.2 %
Cancer type		
Colon	205	63 %
Rectal	78	24 %
Colorectal	43	13 %
Stages		
Stage 1	21	6 %
Stage 2	76	23 %
Stage 3	149	46 %
Stage 4	80	25 %
Total	326	326

Table 2
Burden of colorectal cancer in the study population.

	N	Total cost	Mean	SD
Gender				
Male	187	\$10,658,662.78	\$56,998.20	134,215.89
Female	139	\$8,374,663.62	\$60,249.38	159,962.12
Age				
< 65	233	\$13,894,328.27	\$59,632.31	150,390.36
> 65	93	\$5,138,998.13	\$55,258.04	132,734.92
Cancer type				
Colon	205	\$13,667,472.81	\$66,670.60	125,778.30
Rectal	78	\$3,478,997.26	\$44,602.53	202,020.30
Colorectal	43	\$1,886,856.33	\$43,880.38	99,439.66

Abbreviations: N: No. of patients, SD: Standard Deviation.

Furthermore, the total cost of CRC was higher for patients with colon cancer compared to those with rectal or CRC. Among the different cancer types, colon cancer had the highest total cost, accounting for 72 % (13.6 million) of the total cost, with an average cost of \$66,670 per patient. Fig. 2 shows that the cost per patient increased significantly with advancement in the CRC stage. The average cost per patient was \$45,317 for stage 1, whereas it exceeded \$71,374 for stage 4.

The analysis revealed that medication costs were the primary driver of healthcare spending in the study population, accounting for 45 % of the total costs, followed by surgical costs (27 %). The costs related to hospitalization accounted for 14 % of the total costs, whereas laboratory costs represented 7 %. Radiotherapy costs had the lowest impact on total spending at nearly 2 % (Table 3).

3.1. Estimated the total economic burden of CRC in Saudi Arabia

The estimated total economic burden of CRC in Saudi Arabia. The projection total economic burden of CRC in Saudi Arabia was \$111 million. This cost was incurred from the treatment of 1,908 CRC patients, with 1,045 cases of colon cancer and 863 cases of rectal cancer. The highest cost was observed in the 30–40 years age group, with a total cost of \$42 million, followed by the 45–60 years age group, with a total cost of \$35 million. The total cost for male patients was \$60 million; this was higher than the cost for female patients, which was \$50 million (Figs. 3, 4; Table S1).

4. Discussion

The economic burden of CRC in Saudi Arabia is of critical concern for

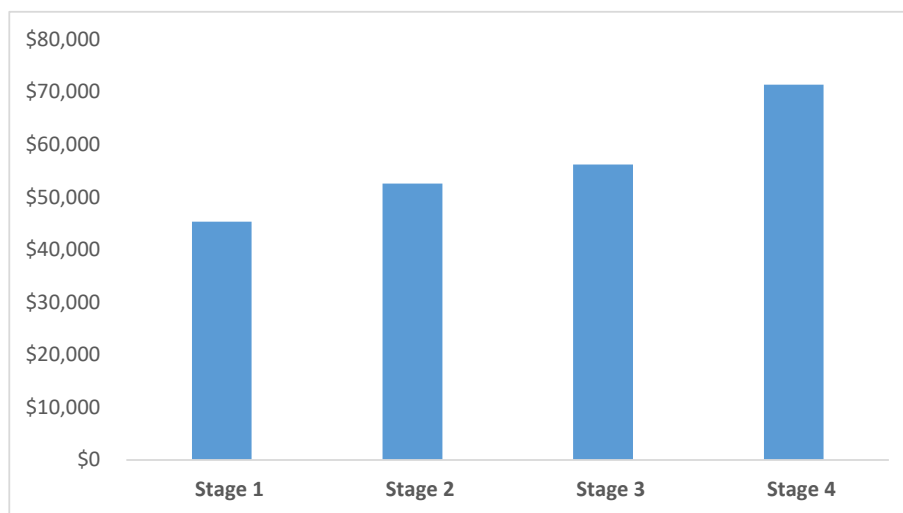


Fig. 2. Annual cost of CRC per disease stages per patient (in USD).

Table 3

Categorization of healthcare resource utilization costs in patients with colorectal cancer.

	Total Cost	Cost per patient	% of total cost
Medication	\$8,564,996.88	\$26,273.00	44 %
Surgery	\$5,138,998.13	\$5,763.80	27 %
Hospital Stay	\$2,664,665.70	\$8,173.82	14 %
Laboratory	\$1,332,332.85	\$4,086.91	7 %
Diagnostic Procedures	\$1,141,999.58	\$3,503.07	6 %
Radiotherapy	\$380,666.53	\$1,167.69	2 %
Total	\$ 19,223,659.66	\$ 58,968.28	100 %

patients, healthcare providers, and policymakers. This study focused on estimating the costs of CRC across different groups (age, gender, and stages of cancer) based on average cost of 326 patients over four years period in the tertiary institution that serves as referral center. Finding of this study shed light on the substantial costs and economic implications associated with CRC treatment in Saudi Arabia.

This study found that the average annual cost per patient was \$58,384.44. This cost increased significantly with the progression of CRC, with the average cost per patient exceeding \$71,374 for stage 4.

(Stark et al., 2020). Although CRC was more common in people aged 65 years and above, the cost of CRC in people younger than 65 years was higher than that in people older than 65 years. These differences could be due to variations in the treatment approaches and overall health status of younger adults versus elderly individuals. Younger adults may have a longer life expectancy and receive more aggressive and intensive treatment regimens, including surgery, chemotherapy, radiation therapy, and targeted therapies. They may also require longer periods of hospitalization, which can result in higher costs.(White et al., 2018) Similar findings have been observed in studies conducted in Germany and Vietnam (Heisser et al., 2022), (Tran et al., 2021). Moreover, a study conducted in China found that the direct medical cost of CRC treatment was significantly higher in younger patients, particularly those aged 20–49 years old, compared to older patients (Liu et al., 2017). This is concerning, as these age groups are considered economically active and crucial for a country’s development. The burden of CRC treatment in these age groups can significantly affect their productivity and quality of life, which may have long-term economic implications (Marosi and Köller 2016, Al-Shandudi et al., 2022). Additionally, the higher cost of younger population could be offset by longer overall survival and higher quality of life and continue pay-back to society. Thus, targeted screening and prevention programs for younger age groups may be particularly

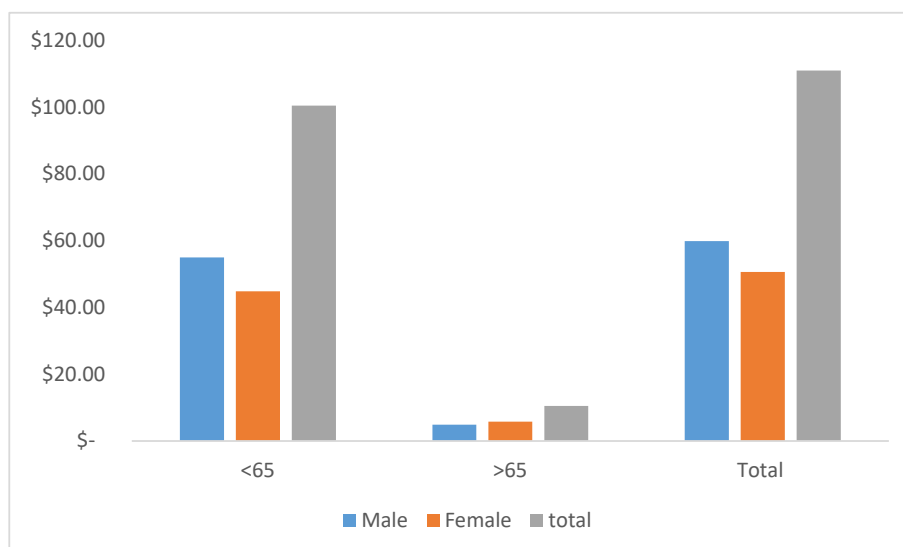


Fig. 3. Estimated the total economic burden of CRC in Saudi Arabia in (\$ million) based on sex and age.

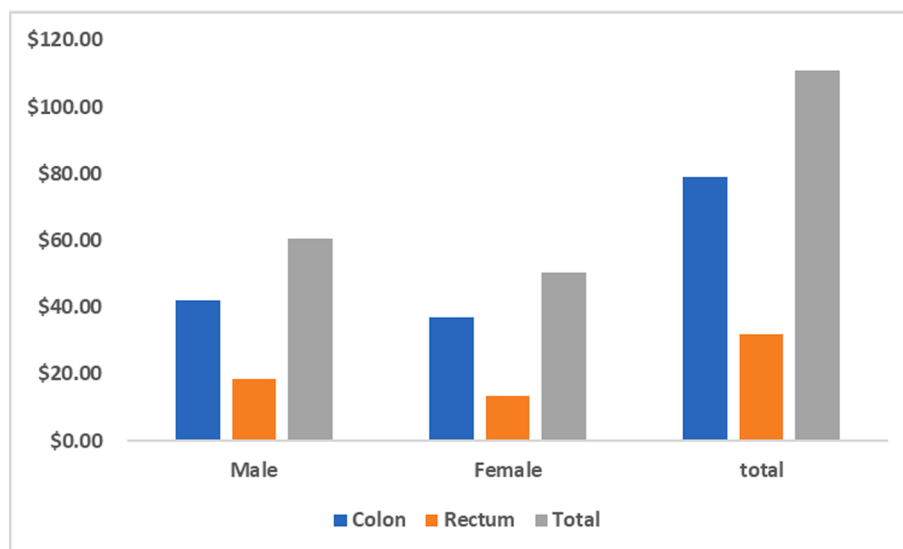


Fig. 4. Total economic burden of CRC in Saudi Arabia in (\$ million) based on cancer type.

effective in reducing the incidence of CRC and its associated economic burden (Siegel et al., 2020). Implementing a population-based CRC screening program and the use of artificial intelligence detection tools in screening colonoscopy led to a reduction in CRC incidence and mortality, resulting in cost savings. (Gini et al., 2020, Areia et al., 2022).

Moreover, the costs of CRC treatment are affected by several other factors, such as cancer stage, tumor site, and treatment strategy. The present findings showed the total costs associated with CRC were higher among male than female patients, with male patients accounting for 56 % of the total cost. This was mainly due to differences in disease prevalence, treatment patterns, and healthcare utilization, as well as the fact that men are more likely to have advanced stage CRC, which requires more expensive treatments. In addition, men may be less likely to seek medical attention early, resulting in delayed diagnosis and the need for expensive treatment options. (White et al., 2018) It's important to note that even though female patients made up a smaller part of the study population, they had higher per-patient costs compared to males. This finding highlights the need to analyze costs for each individual and emphasize the potential impact of gender on the economic burden of CRC treatment.

Furthermore, this study revealed that medication costs were the primary driver of healthcare spending in the study population, accounting for 45 % of the total costs, followed by surgical costs (27 %). This was consistent with previous studies that identified chemotherapy and other targeted therapies as major contributors to the overall cost of cancer care. Furthermore, the increasing use of targeted biological therapies for the treatment of CRC has been associated with rising treatment costs (Kriza et al., 2013). This trend is expected to continue with the advancements in new health technologies. Therefore, it is essential to develop efficient approaches to manage cancer, such as optimizing treatment protocols, enhancing the use of generic and biosimilar drugs, and adopting value-based care models that align with Saudi Arabia's 2030 Health Transformation Plan. This plan aims to develop a sustainable healthcare system that provides high-quality care while optimizing resource utilization. The present study provides valuable information that could inform the development of targeted interventions and policies to reduce the economic burden of cancer treatments in Saudi Arabia. For instance, our findings that medication costs were the primary driver of healthcare spending highlight the need for more cost-effective treatment options that can reduce treatment costs without compromising quality of care.

In addition, this study found that hospitalization costs accounted for 14 % of the total costs, which suggests the importance of developing

strategies to reduce the length of hospital stay and enhance the efficiency of inpatient care. This emphasizes the need for strategies aimed at reducing the length of hospital stay and enhancing the efficiency of inpatient care in CRC. Strategies, such as enhanced recovery after surgery (ERAS) protocols, minimally invasive surgical techniques, and leveraging technology, can help achieve these goals. ERAS protocols are multidisciplinary care pathways designed to optimize preoperative, intraoperative, and postoperative care. (Turaga 2023) Minimally invasive techniques offer faster recovery and lower costs than open surgeries. Moreover, technological advancements, such as telemedicine and remote monitoring, can provide opportunities to monitor patient progress, manage postoperative care, and facilitate early discharge when appropriate. Remote consultations, virtual follow-ups, and monitoring of vital signs and symptoms allow healthcare providers to deliver timely interventions while reducing the need for prolonged hospital stays. By optimizing hospitalization costs, healthcare systems can alleviate the financial burden on patients, enhance resource allocation, and improve overall patient outcomes in CRC management.

Given the increasing pressure on healthcare systems to provide efficient care with scarce resources, understanding the cost burden of cancer is of utmost importance. Within Saudi Arabia, healthcare provisions primarily occur within the public health sector, extending coverage to around 70 % of the population through government-backed health insurance schemes. These programs facilitate access to medical treatments offered by diverse public institutions. Conversely, the remaining 30 % of the population, including both Saudi citizens and expatriates, seek healthcare services from private providers and are obligated to have private health insurance, which is typically provided by their employers. (Alasiri and Mohammed 2022) To address these financial challenges and enable informed decision-making within the healthcare COI studies play a crucial role. A comprehensive understanding of the economic burden of CRC can inform the development of cancer-related policies, with a focus on delivering efficient and effective patient care. Finding of this study highlighted the significant economic burden associated with the treatment of CRC in Saudi Arabia, which was consistent with the findings of previous studies conducted in other countries ((Keum and Giovannucci 2019, Xi and Xu 2021).

The economic burden of colorectal cancer (CRC) is substantial, with estimated costs of INT \$2.8 trillion globally (Chen et al., 2023). European study estimated the total cost of CRC across Europe to be €19.1 billion per year, with healthcare costs accounting for the majority of the expenses (Henderson et al., 2021). Furthermore, the economic burden of CRC is expected to increase in the coming years due to the aging

population in Saudi Arabia, as well as changes in lifestyle factors, such as diet and physical activity. With further advances in health technologies, health expenditure for CRC may increase in the future. The economic burden of CRC may be influenced by a wide range of factors, such as the cost of healthcare services and medications, disease stage at diagnosis, and prevalence of risk factors. It should be noted that healthcare systems and costs may differ significantly across countries, which could explain the differences in economic burden (Kriza et al., 2013). These findings provide insights into disparities in healthcare access and utilization and highlight the need for targeted interventions to address these disparities.

These results indicate that the economic burden of CRC is a global issue requiring immediate attention from policymakers and healthcare practitioners. Healthcare providers and policymakers must consider these economic costs when developing treatment strategies and allocating resources. Future studies should investigate the cost-effectiveness of different treatment options to optimize resource allocation and improve patient outcomes. The high cost of cancer treatment can lead to financial hardship for patients and their families, strain healthcare systems, and limit access to care.

Effective strategies to reduce the economic burden of CRC include increasing awareness about early detection through regular screening (Schlueter et al., 2022). Detecting CRC early, when treatment is most effective and cost-effective, can significantly reduce treatment costs and improve survival rates. The cost per QALY decreases for younger cohorts, reaching \$762 at age 45 or \$2,622 at age 40. Despite escalated screening expenses, the overall CRC management costs decrease. (Kalyta et al.,) These findings support the rationale behind considering earlier CRC screening in revised guidelines, with a necessary assessment of its impact on colonoscopy capacity for well-informed decisions.

In addition, governments and healthcare providers should collaborate to ensure that patients have access to affordable treatments and follow-up care. Another potential strategy for reducing the incidence of CRC is the promotion of healthy lifestyle habits, such as regular physical activity, healthy diet, and avoidance of tobacco and alcohol consumption. Several studies have shown that lifestyle factors can significantly reduce the risk of developing CRC (Carr et al., 2018, Quang et al., 2019).

The present study provides insights into the economic burden of CRC in Saudi Arabia and highlights the need to prioritize cancer control in the country. However, this study has some limitations. The data were collected from a single hospital, which limits the generalizability of the results; thus, the interpretation of the total estimated population costs should be cautious. However, it is important to note that patients with CRC are most likely to receive treatment at tertiary hospitals which often follow similar treatment guidelines and protocols, proposing a possible consistency in the approach to CRC management. While there may be some variations in specific treatment approaches across institutions, the core aspects of care are likely to align with established guidelines. Furthermore, it's worth noting that while costs were often similar in the governmental hospitals, variations may exist in private hospitals. However, the majority of cancer patients still receive their treatment in governmental hospitals due to accessibility and cost considerations. Despite the limitation related to generalization, we believe our study contribute significantly to understanding the economic implications of CRC care in Saudi Arabia. We also believe that our study offers crucial information to policymakers, healthcare providers, and researchers about the financial challenges faced by patients and healthcare systems in managing CRC.

Another limitation is that the economic burden estimated in this study may have been underestimated, as indirect costs, such as lost productivity, caregiver burden, and the emotional and psychological costs of dealing with the disease, were not included in the analysis. A study conducted in Korea indicated that the indirect cost accounted for approximately of 37.15 % of the total cost. (Byun et al., 2014) Therefore, further research is required for a more comprehensive understanding of the economic burden of CRC in Saudi Arabia.

Moreover, the prediction of the total economic burden in Saudi

Arabia is subject to some limitations, including the assumption that the sample of patients from the Saudi Cancer Registry is representative of the general population of CRC patients in Saudi Arabia. Nonetheless, this methodology provides best available and official approach for estimating the economic burden of CRC in Saudi Arabia based on available data from the Saudi Cancer Registry. Despite these limitations, this is the first study to estimate the economic cost of CRC in Saudi Arabia. This was an essential step in guiding future research in this field, informing budget allocation decisions for the national healthcare system, and developing more effective strategies for prevention and prioritization of cancer control.

5. Conclusions

This study provides valuable insights into the economic burden of CRC in Saudi Arabia. It highlights the pressing need to address the financial challenges posed by CRC, particularly among male patients and those under the age of 65. Furthermore, our analysis reveals a clear association between CRC stage and financial burden, with medication costs playing a central role in healthcare spending. The estimated overall economic burden of CRC in Saudi Arabia serves as a compelling call to action, emphasizing the need for strategic resource allocation and cost-effective interventions to ensure the delivery of high-quality care while effectively managing the escalating healthcare costs associated with CRC. Further research is required to identify cost-effective treatment strategies and explore the potential benefits of interventions for improving cancer care outcomes while reducing healthcare costs.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by the Researchers Supporting Project, King Saud University, Riyadh, Saudi Arabia [number RSP2023R76].

Institutional Review Board Statement

This study was approved by the Institutional Review Board committees at KSUMC (IRB number E-19, 26/5/2019).

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jps.2023.101822>.

References

- Alasiri, A. A. and V. Mohammed, 2022. Healthcare transformation in Saudi Arabia: an overview since the launch of vision 2030. *Health services insights*. 15, 11786329221121214.
- Alefan, Q., Saadeh, A., Yaghan, R.J., 2020. Direct medical costs for stage-specific breast cancer: a retrospective analysis. *Breast Cancer Manag.* 9, BMT33.
- Almatroudi, A., 2020. The incidence rate of colorectal cancer in Saudi Arabia: An observational descriptive epidemiological analysis. *Int. J. Gen. Med.* 977–990.
- Al-Shandudi, M., Al-Moundhri, M., Chan, M.F., et al., 2022. Health-related quality of life, functioning, and physical symptoms of adult omani colorectal cancer survivors. *Asian Pac. J. Cancer Prev.* 23, 3019.
- Areia, M., Mori, Y., Correale, L., et al., 2022. Cost-effectiveness of artificial intelligence for screening colonoscopy: a modelling study. *Lancet Digital Health* 4, e436–e444.
- Asiri, S., Asiri, A., Ulahannan, S., et al., 2020. Incidence rates of breast cancer by age and tumor characteristics among Saudi women: Recent trends. *Cureus* 12.
- Bhimani, N., Wong, G.Y., Molloy, C., et al., 2022. Lifetime direct healthcare costs of treating colorectal cancer: a systematic review. *Eur. J. Health Econ.* 1–25.
- Bray, F., Jemal, A., Grey, N., et al., 2012. Global cancer transitions according to the Human Development Index (2008–2030): a population-based study. *Lancet Oncol.* 13, 790–801.

- Byun, J.-Y., Yoon, S.-J., Oh, I.-H., et al., 2014. Economic burden of colorectal cancer in Korea. *J. Prev. Med. Public Health* 47, 84.
- Cancer Registry, Saudi Health Council, 2018. *Cancer Incidence Report In Kingdom of Saudi Arabia*.
- Carr, P.R., Weigl, K., Jansen, L., et al., 2018. Healthy lifestyle factors associated with lower risk of colorectal cancer irrespective of genetic risk. *Gastroenterology* 155 (1805–1815), e1805.
- Chen, S., Cao, Z., Prettner, K., et al., 2023. Estimates and projections of the global economic cost of 29 cancers in 204 countries and territories from 2020 to 2050. *JAMA Oncol.* 9, 465–472.
- Gini, A., Jansen, E.E., Zielonke, N., et al., 2020. Impact of colorectal cancer screening on cancer-specific mortality in Europe: a systematic review. *Eur. J. Cancer* 127, 224–235.
- Heisser, T., Simon, A., Hapfelmeier, J., et al., 2022. Treatment costs of colorectal cancer by sex and age: population-based study on health insurance data from Germany. *Cancers* 14, 3836.
- Henderson, R.H., French, D., Maughan, T., et al., 2021. The economic burden of colorectal cancer across Europe: A population-based cost-of-illness study. *Lancet Gastroenterol. Hepatol.* 6, 709–722.
- Jo, C., 2014. Cost-of-illness studies: concepts, scopes, and methods. *Clin. Mol. Hepatol.* 20, 327.
- Kalyta, A., Y. Ruan, J. J. Telford, et al., Association of Reducing the Recommended Colorectal Cancer Screening Age With Cancer Incidence, Mortality, and Costs in Canada Using OncoSim. *JAMA oncology*.
- Keum, N., Giovannucci, E., 2019. Global burden of colorectal cancer: emerging trends, risk factors and prevention strategies. *Nat. Rev. Gastroenterol. Hepatol.* 16, 713–732.
- Kriza, C., Emmert, M., Wahlster, P., et al., 2013. Cost of illness in colorectal cancer: an international review. *Pharmacoeconomics* 31, 577–588.
- Malila, N., Hakulinen, T., 2003. Epidemiological trends of colorectal cancer in the Nordic countries. *Scand. J. Surg.* 92, 5–9.
- Marosi, C., Köller, M., 2016. Challenge of cancer in the elderly. *ESMO Open* 1, e000020.
- Meropol, N.J., Schrag, D., Smith, T.J., et al., 2009. American Society of Clinical Oncology guidance statement: the cost of cancer care. *J. Clin. Oncol.* 27, 3868–3874.
- Poston, G., D. Tait, S. O'connell, et al., 2011. Diagnosis and management of colorectal cancer: summary of NICE guidance. *bmj.* 343.
- Quang, L. N., N. Q. Hien, N. T. Quang, et al., 2019. Active lifestyle patterns reduce the risk of colorectal cancer in the north of Vietnam: a hospital-based case-control study. *Cancer Control.* 26, 1073274819864666.
- Schluter, D., A. DeGroof, C. Soloe, et al., 2022. Factors that support sustainability of health systems change to increase colorectal cancer screening in primary care clinics: a longitudinal qualitative study. *Health Promotion Practice.* 15248399221091999.
- Siegel, R.L., Jakubowski, C.D., Fedewa, S.A., et al., 2020. Colorectal cancer in the young: epidemiology, prevention, management. *Am. Soc. Clin. Oncol. Educ. Book* 40, e75–e88.
- Stark, U.A., Frese, T., Unverzagt, S., et al., 2020. What is the effectiveness of various invitation methods to a colonoscopy in the early detection and prevention of colorectal cancer? Protocol of a systematic review. *Syst. Rev.* 9, 1–7.
- Statistics, G. A. f., Population in Kingdom by Gender, Age Group, and Nationality.
- Stukalin, I., N. S. Ahmed, A. M. Fundytus, et al., 2022. Trends and Projections in National United States Health Care Spending for Gastrointestinal Malignancies (1996–2030). *Gastroenterology.* 162, 1098–1110. e1092.
- Tran, B.T., Choi, K.S., Nguyen, T.X., et al., 2021. The direct and indirect costs of colorectal cancer in Vietnam: an economic analysis from a social perspective. *Int. J. Environ. Res. Public Health* 18, 12.
- Turaga, A.H., 2023. Enhanced Recovery After Surgery (ERAS) protocols for improving outcomes for patients undergoing major colorectal surgery. *Cureus* 15.
- White, A., Ironmonger, L., Steele, R.J., et al., 2018. A review of sex-related differences in colorectal cancer incidence, screening uptake, routes to diagnosis, cancer stage and survival in the UK. *BMC Cancer* 18, 1–11.
- Xi, Y., Xu, P., 2021. Global colorectal cancer burden in 2020 and projections to 2040. *Transl. Oncol.* 14, 101174.
- Yabroff, K.R., Mariotto, A., Tangka, F., et al., 2021. Annual report to the nation on the status of cancer, part 2: patient economic burden associated with cancer care. *JNCI: J. Nat. Cancer Institute* 113, 1670–1682.