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Survival Rates of Patients Diagnosed with Colorectal Cancer in Costa Rica (2020-2021): A Retrospective Cohort Study at the Centro de Detección Temprana de Cáncer Gástrico

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Abstract

Objective: To evaluate the impact of tumor location, TNM stage, and treatment modalities on survival among colorectal cancer (CRC) patients in Costa Rica (CR). **Design**: Retrospective cohort study. **Setting**: Centro de Detección Temprana de Cáncer Gástrico (CDTCG), Cartago, CR. **Participants**: 101 patients diagnosed with CRC between January 2020 and December 2021, identified from institutional records. **Methods**: Demographic, clinical, histopathological, and treatment data were extracted and analyzed. Survival was assessed using Kaplan–Meier and Cox proportional hazards models, including time-dependent covariates to evaluate variations in treatment effects over time. **Results**: The mean age was 62.5 years; 53.5% were male. Rectal cancer was most frequent (45.5%), and 45% presented with regional disease. FIT-based diagnosis was associated with improved survival (HR: 0.24, p = 0.001). Left-sided tumors showed better prognosis than right-sided (HR: 0.38, p = 0.03). Surgical intervention significantly reduced mortality, particularly in regional-stage disease. Adjuvant therapy initially improved survival (HR: 0.07, p = 0.006) but its benefit declined over time (HR: 4.82, p < 0.001). FOLFOX/XELOX was associated with worse survival, likely reflecting advanced-stage selection bias. **Conclusions**: Early detection, tumor location, and timely surgical intervention are key determinants of CRC survival in CR. Time-dependent analyses highlight the need for ongoing monitoring of treatment effects to optimize

long-term outcomes.

Keywords

Colorectal Cancer, Survival Outcomes, Cancer Screening, Health Disparities

1. Introduction

CRC is a leading cause of cancer incidence and mortality worldwide, with marked regional differences driven by genetic, environmental, and healthcare factors [1] [2]. In CR, incidence has risen steadily, particularly after age 40, reflecting trends in other middle-income countries [3].

Despite the implementation of fecal immunochemical test (FIT)-based screening by the Costa Rican Social Security Fund (CCSS), a substantial proportion of cases are diagnosed at advanced stages, contributing to a national five-year survival rate of ~55% [4] [5].

This retrospective cohort study aimed to assess survival rates of CRC patients diagnosed at the CNDTCG in Cartago between 2020 and 2021. We evaluated demographic, clinical, and pathological characteristics, treatment modalities, and outcomes, and compared FIT-detected cases with those diagnosed through other pathways to determine their impact on stage at diagnosis and prognosis. Findings are intended to inform public health policy and improve CRC screening strategies in CR.

2. Methods

2.1. Study Design and Population

This retrospective cohort study evaluated survival outcomes and prognostic factors in patients diagnosed with CRC at the CNDTCG in Cartago, CR, between January 1, 2020, and December 31, 2021. The study included all consecutive patients with biopsy-confirmed CRC recorded in the institutional pathology registry during this period. Cases with incomplete clinical or pathological data or without histological confirmation were excluded.

2.2. Ethical Considerations

The study was approved by the Scientific Ethics Committee under protocol number HNN-DG-CEC-045-2025. All data were anonymized before analysis, and confidentiality was maintained in accordance with national regulations.

2.3. Data Collection and Processing

Clinical and pathological data were extracted from biopsy reports and hospital medical records. Data were entered into an Excel 97-2003 spreadsheet and analyzed using Stata version 18. Variables with missing values were analyzed by com-

plete-case analysis; no data imputation was performed.

2.4. Variables and Definitions

Demographic variables included age, sex, and canton of residence. Clinical variables comprised symptoms at diagnosis (e.g., rectal bleeding, abdominal pain, weight loss), tumor localization, and TNM stage (6th edition). Tumor location was classified as right colon (cecum, ascending colon, hepatic flexure), left colon (descending colon, sigmoid colon), rectum, or anal canal/anus.

Treatment variables included type of surgical procedure (colectomy, colostomy, low anterior resection [LAR], abdominoperineal resection [APR], sigmoidectomy) and surgical approach (laparoscopic vs. open). Adjuvant therapy regimens included capecitabine monotherapy, FOLFOX, XELOX, chemoradiotherapy, and bevacizumab-based combinations. Postoperative complications were recorded and categorized by severity.

Lymph node involvement was classified as: none (0), low (1 - 3 nodes), moderate (4 - 6 nodes), or high (≥7 nodes). TNM stages were grouped into:

1) Early (Localized): Tis, T1, or T2; N0; M0.

2) Regional: T3, T4, N1, or N2; M0.

3) Advanced (Metastatic): M1, regardless of T or N.

4) Unclassified/Unknown: incomplete or missing TNM data.

2.5. Outcomes

The primary outcome was overall survival, defined as time from diagnosis to death from any cause or last follow-up. Disease-free survival was analyzed where applicable.

2.6. Statistical Analysis

Categorical variables were summarized as frequencies and percentages, and continuous variables as means with standard deviations or medians with interquartile ranges. Kaplan–Meier curves were generated to estimate survival probabilities. Cox proportional hazards regression was used to evaluate associations between prognostic variables and survival, reporting hazard ratios (HR) with 95% confidence intervals (CI).

Three models were constructed:

- Model 1: adjusted for age, sex, and place of residence.
- Model 2: additionally adjusted for treatment variables.
- Model 3: included interaction terms between TNM stage and treatment.

Time-dependent Cox models were applied to evaluate changes in treatment effects over time. Chi-square tests compared observed versus expected events across tumor locations. A p-value < 0.05 was considered statistically significant.

3. Results

A total of 101 patients with CRC were included between January 2020 and De-

cember 2021. The mean age was 62.49 years (SD ±13.09; range: 32 - 91), and 53.47% were male. Most patients resided in Cartago city (22.77%), El Guarco (15.84%), and Paraíso (13.86%). At diagnosis, 78% presented with symptoms (Table 1). The mean time from diagnosis to treatment was 61 days, and the mean follow-up time was 30 months.

Table 1. General characteristics.

Variable	Category	Frequencies (#)	Percentage (%)	Accumulate (%)
Sex	Women	47	46.53	46.53
	Men	*54*	*53.47*	*100*
Residence	*CARTAGO*	*23*	*22.77*	*22.77*
	EL GUARCO	16	15.84	38.61
	PARAISO	14	13.86	75.25
	OREAMUNO	10	9.9	61.39
	TURRIALBA	10	9.9	90.1
	ZONA SUR	10	9.9	100
	LA UNION	9	8.91	51.49
	SAN JOSE	5	4.95	80.2
	JIMENEZ	4	3.96	42.57
Symptom	No	22	21.78	21.78
	Yes	*79*	*78.22*	*100*

Variable	Obs.	Mean	SD	Min	Max
Age	101	62.49	13.09	32	91
Dx-Tx	90	60.68	72.1	0	335
Survival Time	100	29.52	17.9	0	56

Dx-Tx: Time from Diagnosis to Treatment.

3.1. Diagnosis Pathways and Stage at Presentation

Thirty-six patients (35.64%) were diagnosed through FIT screening, and 65 (64.36%) through other means. FIT-detected cases were more frequently diagnosed at early stage (41.67% vs. 6.25%), while non-FIT cases were more often regional (51.56%) or advanced (29.69%) (Table 2).

Table 2. Screening methods versus stages.

Diagnosis Method	Total	Percentage of Total	Early (%)	Regional (%)	Advanced (%)
FIT Screening	36	35.64	41.67	33.33	8.33
Other Methods	64	64.36	6.25	51.56	29.69

3.2. Tumor and Histopathological Characteristics

Tumor location was most frequently the rectum (45.54%), followed by the right

colon (26.73%), left colon (24.75%), and anal canal (2.97%) (Table 3). TNM staging showed 45% regional disease, 22% metastatic, 19% localized, and 14% unclassified. Adenocarcinoma was the predominant histology (91.09%), with less frequent types including intramucosal carcinoma (3.96%), signet-ring cell carcinoma (1.98%), and other subtypes (2.97%).

Table 3. Tumor characteristics.

TNM Stage Grouped	Frequency	Percent	Cumulative
Advanced (Metastatic)	22	22	22
Early (Localized)	19	19	41
Regional (*Lymph Node Involvement*)	*45*	*45*	*86*
Unclassified/Unknown	14	14	100
Localization	**Freq.**	**Percent**	**Cum.**
Right Colon	27	26.73	26.73
Left Colon	25	24.75	51.49
Rectum	*46*	*45.54*	*97.03*
Anal Canal/Anus	3	2.97	100
Biopsy Result	**Frequency**	**Percent**	**Cumulative**
Carcinoma	*92*	*91.09*	*91.09*
Intramucosal	4	3.96	95.05
Signet-Ring Cells	2	1.98	97.03
Others	3	2.97	100
Nodes Positive (Grouped)	**Frequency**	**Percent**	**Cumulative**
None (*0*)	*86*	*85.15*	*85.15*
Low (1 - 2)	11	10.89	96.04
High (≥3)	4	3.96	100

3.3. Stage-Location Relationship

Rectal cancer was commonly diagnosed at regional (56.52%) or advanced (26.09%) stages. Early-stage tumors were more frequent in the left colon (32%) and right colon (23.08%) (Table 4). Unclassified staging was more common in the right colon (26.92%), likely due to incomplete data.

3.4. Observed vs. Expected Mortality

The chi-square test showed a marginally non-significant difference in mortality distribution by location ($\chi^2 = 6.95$, $p = 0.0736$). Rectal cancer mortality matched expectations (observed: 21; expected: 22.90), whereas right colon had more deaths than expected (15 vs. 9.89), and left colon fewer (7 vs. 11.86).

Table 4. Localization by Stage TNM.

	Advanced (%)	Early (%)	Regional (%)	Unclassified (%)	Total (%)
Right Colon	4 (15.4)	6 (23.1)	9 (34.6)	**7 (26.9)**	26 (26.8)
Left Colon	5 (20)	**8 (32)**	8 (32)	4 (16)	25 (24.7)
Rectum	12 (26.2)	5 (10.1)	**26 (56.5)**	3 (6.5)	**46 (45.5)**
Anal Canal/Anus	**1 (33.4)**	0 (0)	2 (66.7)	0 (0)	3 (3)
Total	22 (22)	19 (19)	45 (45)	14 (14)	100 (100)

3.5. Treatment Patterns

Surgery was performed in 75.25% of patients; colectomy (25.74%), colostomy (19.80%), and LAR (17.82%) were most common. Laparoscopic surgery was used in 40.59% of cases. Postoperative complications occurred in 21.78% of patients. Adjuvant therapy was given to 46.53%, most frequently FOLFOX/XELOX (23.76%), capecitabine monotherapy (6.93%), and chemoradiotherapy (6.93%) (Table 5).

Table 5. Treatments.

Surgical Treatment	Frequency	Percent	Cumulative
Others/unknown	25	24.75	24.75
Colectomy	*26*	*25.74*	*50.50*
Colostomy	20	19.80	70.30
LAR	18	17.82	88.12
APR	2	1.98	90.1
Sigmoidectomy	10	9.9	100
Laparoscopy	**Frequency**	**Percent**	**Cumulative**
No	*60*	*59.41*	*59.41*
Yes	41	40.59	100
Total	101	100	-
Complications	**Frequency**	**Percent**	**Cumulative**
No	*79*	*78.22*	*78.22*
Yes	22	21.78	100
Total	101	100	-
Adjuvant Therapy	**Frequency**	**Percent**	**Cumulative**
No	*54*	*53.47*	*53.47*
Yes	47	46.53	100
Total	101	100	-
Chemotherapy Groups	**Frequency**	**Percent**	**Cumulative**
No chemotherapy	*51*	*50.50*	*91.09*
Capecitabine	7	6.93	57.43
FOLFOX/XELOX	24	23.76	81.19

Continued

Chemoradiotherapy	7	6.93	88.12
Bevacizumab	5	4.95	93.07
Others	7	6.93	100

Low Anterior Resection (LAR), Abdominoperineal Resection (APR).

3.6. Survival Analysis

Early-stage tumors had better survival (HR: 0.10, 95% CI: 0.02 - 0.52, p = 0.00) than unclassified cases. Localized disease showed a protective trend (HR: 0.45, 95% CI: 0.18 - 1.08, p = 0.07), while advanced disease had worse prognosis (HR: 1.76, 95% CI: 0.73 - 4.23, p = 0.20) (Table 6, Figure 1).

Table 6. Cox regression models.

	HR	SE	z	p	LCI	HCI
Unclassified			*Reference*			
Early	0.10	0.08	−2.76	0.00	0.02	0.52
Localized	0.45	0.20	−1.77	0.07	0.18	1.08
Advanced	1.76	0.78	−1.28	0.20	0.73	4.23
	HR	**SE**	**z**	**P**	**LCI**	**HCI**
NO Laparoscopy			*Reference*			
Laparoscopy	0.48	0.15	−2.21	0.27	0.25	0.92
	HR	**SE**	**z**	**P**	**LCI**	**HCI**
Other Methods			*Reference*			
FIT Screening	0.24	0.09	−3.44	0.001	0.10	0.54
	HR	**SE**	**z**	**p**	**LCI**	**HCI**
Carcinoma			*Reference*			
Intramucosal	0.44	0.45	−0.80	0.42	0.06	3.23
Ring cells	4.61	3.38	2.08	0.03	1.09	19.43
Others	1.85	1.34	0.85	0.395	0.44	7.69
	HR	**SE**	**z**	**p**	**LCI**	**HCI**
Right Colon			*Reference*			
Left Colon	0.38	0.17	−2.07	0.03	0.15	0.94
Rectum	0.60	0.20	−1.50	0.13	0.30	1.16
Anal Canal/Anus	1.46	0.92	−0.60	0.54	0.42	5.07
	HR	**SE**	**z**	**p**	**LCI**	**HCI**

FIT-based diagnosis was strongly associated with improved survival (HR: 0.24, 95% CI: 0.11 - 0.54, p = 0.001; log-rank p = 0.0001) (Table 6, Figure 2). Left-sided CRC had significantly better survival than right-sided (HR: 0.38, 95% CI: 0.15 - 0.94, p = 0.03) (Figure 3).

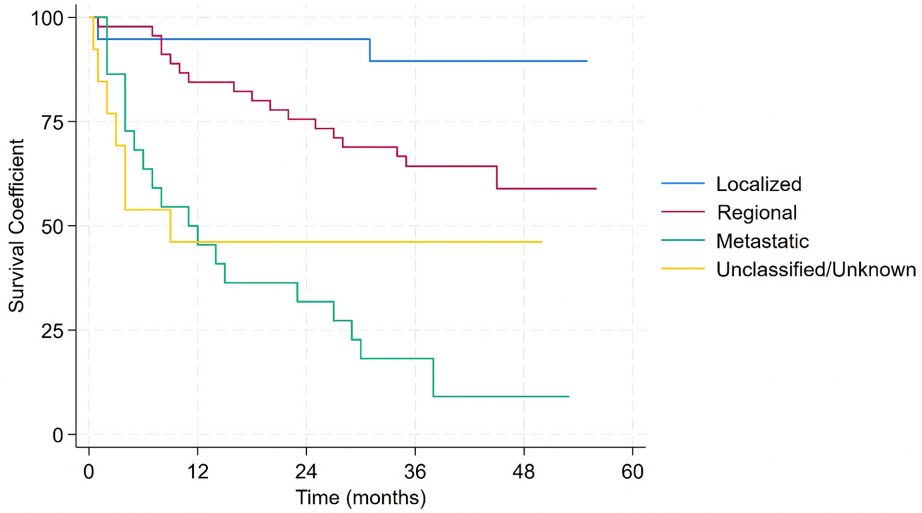

Figure 1. Kaplan Meier survival rates by TNM.

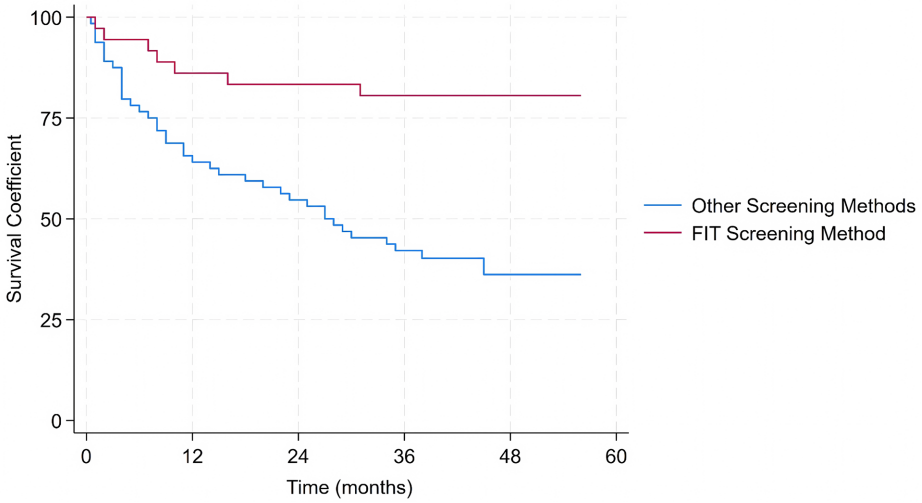

Figure 2. Kaplan Meier survival rates by FIT status.

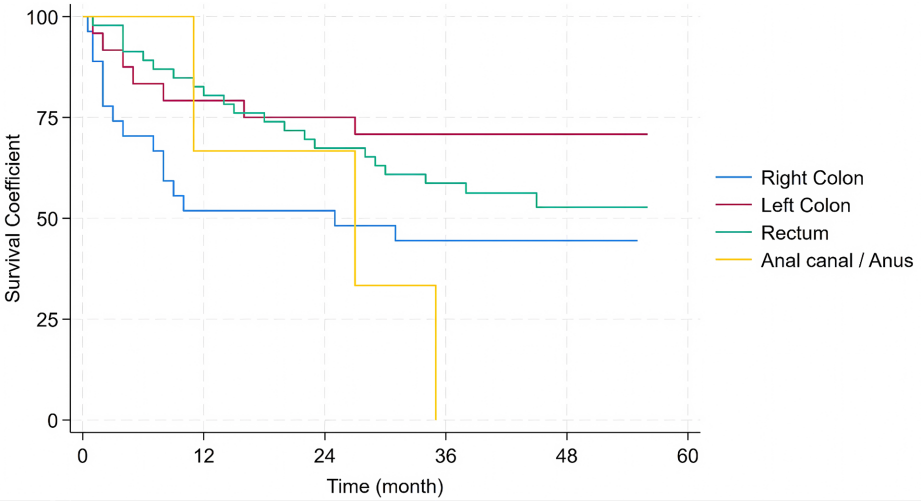

Figure 3. Kaplan Meier survival rates by tumor localization.

3.7. Time-Dependent Effects

Time-dependent Cox models showed initial strong survival benefits for colectomy (HR: 0.027, p = 0.007), colostomy (HR: 0.032, p = 0.004), and APR (HR: 0.00008, p = 0.023), but these effects diminished or reversed over time, suggesting late complications or reduced benefit.

Chemotherapy regimens also showed early benefit but declining effects:

- FOLFOX/XELOX: early HR 0.67 (p = 0.017) → later HR 6.92 (p = 0.001)
- Chemoradiotherapy: early HR 0.012 (p = 0.081) → later HR 9.68 (p = 0.013)
- Bevacizumab: early HR 0.008 (p = 0.147) → later HR 10.07 (p = 0.047)

When analyzed overall, FOLFOX/XELOX was associated with higher mortality (HR: 2.82, 95% CI: 1.44 - 5.53, p = 0.00), likely reflecting its use in advanced cases rather than intrinsic inefficacy (Table 7).

Table 7. Time-dependent cox regression models for surgical and chemotherapy treatments.

	Initial Values				Time Dependent Values			
	HR	95% CI		P (val.)	HR	95% CI		P (val.)
Colectomy	0.027	0.01	0.38	0.007	2.97	0.96	9.14	0.058
Colostomy	0.032	0.00	0.32	0.004	5.07	1.84	13.94	0.002
RAB	0.00008	0.00	0.26	0.023	18.69	1.41	246.4	0.023
	HR	95% CI		P (val.)	HR	95% CI		P (val.)
FOLFOX/XELOX	0.67	0.01	0.62	0.017	6.92	2.39	20.65	0.001
Qx-Rx	0.01	0.00	1.71	0.081	9.68	1.60	58.54	0.013
Bevacizumab	0.008	0.00	5.26	0.147	10.07	1.01	109.3	0.047

Val.: Values, Qx-Rx: Chemoradiotherapy.

4. Discussion

This study provides relevant evidence on CRC prognosis in CR, emphasizing the influence of tumor localization, stage at diagnosis, and treatment modalities—including time-dependent effects—on survival. The results highlight the importance of early detection through FIT-based screening and the potential survival benefits of tailored surgical and adjuvant treatment strategies.

4.1. Impact of FIT-Based Screening

Patients diagnosed with FIT screening were more likely to have early-stage disease (41.67% vs. 6.25%) compared with those diagnosed through other pathways, consistent with previous studies reporting improved early detection and reduced mortality through FIT programs [6]-[9]. Although the hazard ratio for mortality among FIT-detected cases did not reach statistical significance (HR: 0.88, p = 0.726), the limited sample size may have reduced statistical power. Conversely, patients diagnosed outside FIT programs had a markedly worse prognosis (HR: 5.56, p < 0.001), reinforcing the established association between late-stage diag-

nosis and poor survival [10] [11]. Strengthening FIT-based screening coverage and adherence could increase early detection rates and improve long-term outcomes.

4.2. Tumor Localization and Survival

Rectal cancer was the most frequent location (45.54%), contrasting with patterns from high-income countries where left-sided CRC predominates [12] [13]. This could reflect genetic, environmental, or healthcare access differences in CR. Rectal tumors were often diagnosed at regional (56.52%) or advanced (26.09%) stages, underscoring possible diagnostic delays or aggressive biology. Left-sided CRC showed significantly better survival (HR: 0.38, $p = 0.03$) than right-sided tumors, aligning with evidence that right-sided CRC is less responsive to standard treatments [14]-[16]. Although differences in survival by location did not reach statistical significance (log-rank $p = 0.0736$), trends support the relevance of anatomical site in prognosis and treatment planning.

4.3. Surgical and Adjuvant Treatments

Surgery remained a strong determinant of survival. Colectomy, low anterior resection, and sigmoidectomy were associated with improved outcomes, with laparoscopic surgery showing a protective effect (HR: 0.48, $p = 0.02$), in line with literature on the benefits of minimally invasive techniques [17]. Time-dependent analysis revealed that initial survival benefits of colectomy and colostomy diminished over time, suggesting possible late complications or reduced efficacy in advanced disease.

Adjuvant therapy demonstrated time-dependent benefits, with protective effects increasing during follow-up (HR: 1.54, $p = 0.004$). However, FOLFOX/XELOX regimens were associated with worse overall survival (HR: 2.82, $p = 0.00$), likely due to indication bias as these regimens are often used in advanced cases. This underlines the importance of patient stratification and individualized therapy [18].

4.4. Lymph Node Involvement and Complications

Neither lymph node involvement nor postoperative complications significantly affected survival in this cohort, suggesting that other factors—such as tumor biology and systemic inflammation—may have greater prognostic weight.

4.5. Clinical Implications

The high proportion of late-stage rectal cancer cases supports revising screening strategies to improve detection in this location. Surgical decisions should consider both stage and patient characteristics, while structured follow-up programs could maximize the time-dependent benefits of adjuvant therapy.

4.6. Future Research

Further studies should explore molecular differences between right- and left-sided

CRC, integrate tumor location into risk models, and assess novel therapeutic approaches including neoadjuvant and immunotherapy. Large-scale, prospective research is needed to validate these findings and guide personalized CRC management in CR.

5. Conclusions

Rectal cancer in this cohort was most often diagnosed at regional or advanced stages, a finding associated with poorer survival and indicative of potential delays in detection. Conversely, left-sided CRC showed a survival advantage over right-sided tumors, supporting the need for location-specific diagnostic and therapeutic strategies.

Surgical intervention, particularly in regional-stage disease, significantly improved survival, with laparoscopic approaches providing additional benefits by reducing perioperative morbidity. Adjuvant therapy demonstrated a sustained protective effect over time, underscoring its value in long-term disease control and patient follow-up.

The association between FOLFOX/XELOX chemotherapy and poorer survival likely reflects selection bias, as this regimen is typically reserved for advanced-stage cases.

Future research should focus on the interplay between tumor location, stage, and treatment effectiveness to refine patient stratification models and advance personalized CRC management. These results highlight the critical importance of early detection, optimal treatment selection, and structured long-term follow-up in improving colorectal cancer survival outcomes.

6. Limitations

This study has several limitations. First, its retrospective design may be subject to selection bias, as only patients with complete medical records and histological confirmation were included. Second, missing data on certain clinical and pathological variables—particularly TNM stage in unclassified cases—may have affected the accuracy of stage-specific analyses. Third, the relatively small sample size may have limited the statistical power to detect subgroup differences, particularly in time-dependent models. Fourth, the study was conducted in a single specialized center, which may limit the generalizability of the findings to other healthcare settings in CR. Finally, the observational nature of the study precludes definitive causal inferences regarding treatment effects.

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Ethics Statement

The study protocol was reviewed and approved by the Scientific Ethics Committee of the Hospital Nacional de Niños under protocol number HNN-DG-CEC-045-2025. Given the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived in accordance with national and institutional regulations. All procedures were conducted in accordance with the principles of the Declaration of Helsinki and Costa Rican ethical guidelines for human research.

Patient and Public Involvement

Patients and members of the public were not involved in the design, conduct, reporting, or dissemination plans of this research. The study relied exclusively on secondary analysis of existing clinical and pathological data from institutional registries.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to institutional confidentiality agreements and patient privacy regulations. De-identified data may be made available from the corresponding author upon reasonable request and with approval from the CCSS and the Scientific Ethics Committee.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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