



Financial Impact of Out-of-Pocket Costs Among Patients Undergoing Resection for Colorectal Carcinoma

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ABSTRACT

Introduction. Little is known about the societal burden of cancer surgical care in terms of out-of-pocket (OOP) costs. The current study sought to define OOP costs incurred by patients undergoing colorectal cancer resection.

Methods. Privately insured patients undergoing colorectal cancer resection between 2013 and 2017 were identified from the IBM MarketScan database. Total and OOP costs were calculated within 1 year prior to and 1 year post surgery. A multivariable linear regression model was used to estimate total OOP costs relative to patient demographic and clinical characteristics.

Results. Among 10,935 patients, 7289 (66.7%) had primary colon cancer while 3643 (33.3%) had rectal cancer. Median total costs were US\$93,967 (IQR US\$51,027–168,251). Median OOP costs were US\$4417 (IQR US\$2519–6943), or 4.5% (IQR 2.2–8.1%) of total costs. OOP costs varied over the course of patient care; specifically, median OOP costs in the preoperative period were US\$432 (IQR US\$130–1452) versus US\$2146 (IQR US\$851–3525) in the perioperative period and US\$969 (IQR US\$327–2239) in the postoperative period. On multivariable analysis, receipt of chemotherapy (+US\$1368, 95%CI +US\$1211 to +US\$1525) or radiotherapy (+US\$842, 95% CI +US\$626 to +US\$1059) was associated with higher total OOP costs. Patients with a health maintenance organization (HMO) (–US\$2119, 95% CI

–US\$2550 to –US\$1689) or a point-of-service plan (–US\$938, 95% CI –US\$1385 to –US\$491) had lower total OOP costs than patients with comprehensive insurance. In contrast, patients with a consumer-driven or a high-deductible health plan had considerably higher total OOP costs than patients with comprehensive insurance (+US\$1400, 95% CI +US\$972 to +US\$1827 and +US\$3243, 95% CI +US\$2767 to +US\$3717, respectively).

Conclusions. Privately insured colorectal cancer patients undergoing surgical resection pay a median of US\$4417 in OOP costs, or 4.5% of total costs. OOP costs varied with receipt of chemotherapy or radiotherapy, region of residence, and insurance plan type.

Cancer represents the second leading cause of death in the USA, and costs associated with its treatment constitute a significant portion of total US healthcare spending.^{1,2} Specifically, costs associated with cancer care amounted to US\$183 billion in 2015 and are projected to increase to US\$246 billion by 2030.³ Despite the introduction of annual out-of-pocket (OOP) limits in 2014, cancer patients are responsible for paying a significant share of total cancer treatment costs.⁴ In 2018 alone, cancer patients paid US\$5.8 billion OOP for cancer treatment.⁵ Such high OOP costs can often lead to financial hardship among cancer patients and survivors.^{6,7} In turn, cancer patients who experience financial hardship report worse health outcomes, including increased symptoms, decreased satisfaction with care, lower quality of life, and higher mortality.^{8–11} Notably, costs associated with cancer care do not impact all cancer patients equally. Patients of color, as

well younger or less educated individuals are more likely to experience financial hardship following a cancer diagnosis.¹²

Colorectal cancer represents the third most common cancer and the second leading cause of cancer-related death in the USA.^{13,14} Its treatment commonly involves a combination of surgical resection, chemotherapy, and/or radiotherapy, resulting in substantial costs.¹⁵ As such, the associated OOP costs can result in financial strain among colorectal cancer patients and survivors.^{16,17} Most literature and public discourse on the financial hardship experienced by patients as a result of OOP costs has focused on the cost of drug treatments.^{18–20} Several studies have noted that OOP costs associated with cancer care spike immediately following diagnosis due to the high OOP costs relative to inpatient services, including surgery for potentially resectable cancers.²¹ OOP costs experienced by colorectal cancer patients who undergo surgical treatment remain poorly defined, however. As such, the objective of the current study is to determine total OOP costs among privately insured colorectal cancer patients incurred between 1 year prior to and 1 year following surgery. Additionally, we sought to identify the demographic and clinical factors associated with total OOP costs over this time period.

METHODS

Patient Population

Patients with colorectal cancer who underwent surgical resection between 2013 and 2017 were identified from the commercial IBM MarketScan database, which contains medical and drug data retrieved from employers and health plans for more than 203 million individuals annually.²² Patients diagnosed with colon or rectal cancer were identified using the corresponding codes of the International Classification of Diseases, 9th and 10th revisions (ICD-9 and ICD-10) (Supplementary Table 1). Patients who underwent surgical resection of their primary tumor were identified using a combination of ICD-9, ICD-10, and Common Procedural Terminology (CPT) codes (Supplementary Table 2). Patients with an additional cancer diagnosis were excluded. Additionally, patients without continuous enrollment and drug coverage over the study period (from 12 months before surgery to 12 months following surgery) were excluded.

Variables and Outcomes

Variables of interest included patient age, sex, employment status (active full time, active part time,

Consolidated Omnibus Budget Reconciliation Act (COBRA) continuee, etc.), health insurance type, and US Census Bureau region of residence, as well as whether patients resided in a Metropolitan Statistical Area (MSA). Patient health insurance types included comprehensive health coverage, exclusive provider organization (EPO), health maintenance organization (HMO), point-of-service (POS) plans, preferred provider organization (PPO), consumer-directed health plans (CDHP), and high-deductible health plans (HDHP). The 2010 Standards for delineating MSA require that the area must have at least one urbanized region of 50,000 or more inhabitants.²³ In the current study, residence in a MSA was used as a proxy for residence in an urban setting. Preoperative comorbidities were accounted for using the Charlson Comorbidity Index (CCI).^{24–26} Information on treatment included year of surgery as well as receipt of chemotherapy and/or radiotherapy. Patients who received chemotherapy or radiotherapy were identified using the relevant revenue and CPT codes.

Total costs were calculated as the sum of all healthcare expenditures between 12 months prior to surgery and 12 months following surgery, including costs reimbursed by the primary insurance provider, out-of-pocket (OOP) costs incurred by the patient, as well as benefits received by other insurance carriers. OOP costs were calculated as the sum of deductibles, copayments, and coinsurance, as available in the IBM MarketScan commercial database. The proportion of OOP costs relative to total costs (OOP/total) was then calculated.

Total costs were the sum of expenditures associated with claims over four distinct time periods: the preoperative (from 1 year prior to surgery to 90 days prior to surgery), the perioperative (from 90 days prior to surgery to 30 days following surgery), the adjuvant (from 30 days following surgery to 90 days following surgery), and the surveillance period (from 90 days following surgery to 1 year following surgery). The definition of these four time periods was consistent with previous studies on OOP costs among cancer patients undergoing surgery.²⁷

Statistical Analysis

Descriptive statistics are presented as median (interquartile range, IQR) for continuous variables and frequency (relative frequency, %) for categorical variables. Bivariate associations between cancer location (colon or rectum) and patient demographic or clinical characteristics were assessed using Kruskal–Wallis one-way analysis of variance for continuous variables and chi-squared tests for categorical variables. A multivariable linear regression model was developed to predict the overall OOP costs over the study period based on relevant patient demographic and

clinical characteristics. All analyses were performed using SAS version 9.4. Statistical significance was assessed at $\alpha = 0.05$.

RESULTS

Patient Characteristics

Among 10,935 patients who underwent surgical resection for colorectal cancer between 2013 and 2017, median age was 55 years (IQR 50–59 years), and slightly more than one-half of patients were male ($n = 5673$, 51.9%) (Table 1). Approximately four in ten patients received chemotherapy ($n = 5100$, 46.6%), while fewer than two in ten patients underwent radiotherapy ($n = 1877$, 17.2%). Patients were most commonly from the South ($n = 5122$, 46.8%), followed by the Midwest ($n = 2166$, 19.8%), the Northeast ($n = 2010$, 18.4%), and the West ($n = 1523$, 13.9%). Additionally, the vast majority of patients resided in an MSA ($n = 9000$, 82.3%). At the time of surgery, more than five in ten patients were actively employed full time ($n = 6057$, 55.4%), while one in ten patients were retired ($n = 1216$, 11.1%). Only a small minority of patients were employed part time ($n = 88$, 0.8%); employment status was unknown in a subset of individuals ($n = 3458$, 31.6%). The most common health insurance type was PPO ($n = 6549$, 59.9%), followed by CDHP ($n = 1153$, 10.5%), HMO ($n = 1130$, 10.3%), and POS ($n = 886$, 8.1%).

The majority of patients underwent resection for colon cancer ($n = 7289$, 66.7%), while other individuals had resection for rectal cancer ($n = 3643$, 33.3%) (Table 1). Patients with rectal cancer were more often male (55.4% vs. 50.1%), as well as were more likely to receive chemotherapy (57.8% vs. 41.0%) or radiotherapy (45.2% vs. 3.1%) versus patients with colon cancer (all $p < 0.001$). Additionally, patients with rectal cancer more often underwent resection in the earlier years of the study period (2013: 37.1% vs. 27.3%; 2014: 25.7% vs. 20.2%; $p < 0.001$) compared with patients who had colon cancer.

Total and Out-of-Pocket Costs

Median total costs associated with all claims between 1 year preoperatively and 1 year postoperatively were US\$93,967 (IQR US\$51,027–168,251). Median OOP costs over the same period were US\$4417 (IQR US\$2519–6943), or 4.5% (IQR 2.2–8.1%) of total costs. Median total costs fluctuated considerably over the study period. Specifically, costs started at US\$1921 (IQR US\$543–11,336) in the preoperative period, peaked at US\$44,723 (IQR US\$32,398–65,575) in the perioperative period, and then decreased to US\$9647 (IQR

US\$1031–24,714) in the adjuvant period, only to rise again to US\$21,327 (IQR US\$4749–60,591) in the postoperative period (Table 2). OOP costs followed a similar trend, going from US\$432 (IQR US\$130–1452) in the preoperative period to US\$2146 (IQR US\$851–3525) in the perioperative period, US\$200 (IQR US\$71–640) in the adjuvant period, and US\$969 (IQR US\$327–2239) in the postoperative period (Table 2; Fig. 1). Notably, OOP costs represented a higher proportion of total costs in the preoperative period (17.9%, IQR 7.6–36.1%) compared with all subsequent periods (perioperative: 4.5%, IQR 1.7–8.7%; adjuvant: 4.0%, IQR 1.1–13.8%; postoperative: 5.1%, IQR 1.8–14.5%).

When costs were stratified by service type, inpatient services were associated with much higher OOP costs compared with outpatient services (Table 2; Fig. 1). In particular, OOP costs associated with inpatient services amounted to US\$1300 (IQR US\$480–2453) in the preoperative period, US\$1338 (IQR US\$534–2440) in the perioperative period, US\$433 (IQR US\$200–1203) in the adjuvant period, and US\$845 (IQR US\$291–2001) in the postoperative period. These OOP costs constituted a greater proportion of the total costs in the preoperative period (6.4%, IQR 2.1–14.2%) than in all subsequent periods (perioperative: 4.0%, IQR 1.6–8.0%; adjuvant: 2.0%, IQR 0.9–6.2%; postoperative: 2.5%, IQR 0.9–6.8%). OOP costs associated with outpatient services were lower and affected far fewer patients, amounting to US\$400 (IQR US\$126–1266) in the preoperative period, US\$812 (IQR US\$300–1672) in the perioperative period, US\$190 (IQR US\$70–576) in the adjuvant period, and US\$847 (IQR US\$303–1982) in the postoperative period. Similar to OOP costs associated with inpatient services, these OOP costs represented a greater proportion of total costs in the preoperative period (18.4%, IQR 8.0–36.7%) compared with all subsequent periods (perioperative: 9.2%, IQR 3.5–17.9%; adjuvant: 4.5%, IQR 1.2–14.6%; postoperative: 5.9%, IQR 2.1–15.4%).

Only a small minority of patients had OOP costs associated with receipt of chemotherapy or radiotherapy (Table 2). Among the patients who did have OOP costs, OOP costs associated with chemotherapy amounted to US\$71 (IQR US\$16–747) in the preoperative period, US\$42 (IQR US\$10–216) in the perioperative period, US\$137 (IQR US\$40–547) in the adjuvant period, and US\$205 (IQR US\$53–768) in the postoperative period. These OOP costs translate to 4.8% (IQR 1.2–13.3%) of total costs in the preoperative period, 10.0% (IQR 2.7–20.0%) in the perioperative period, 7.9% (IQR 2.8–18.4%) in the adjuvant period, and 4.0% (IQR 1.4–10.9%) in the postoperative period. OOP costs associated with radiotherapy were higher, amounting to US\$374 (IQR US\$140–921) in the preoperative period,

TABLE 1 Patient demographic and clinical characteristics, as well as details about their insurance and employment status, by cancer type

Variable	Total (n = 10,935)	Colon cancer (n = 7289, 66.7%)	Rectal cancer (n = 3643, 33.3%)	p-Value
Age (years)	55 (50, 59)	55 (50, 60)	54 (48, 59)	< 0.001
Male	5673 (51.9%)	3653 (50.1%)	2020 (55.4%)	< 0.001
Year of surgery				< 0.001
2013	3341 (30.6%)	1988 (27.3%)	1353 (37.1%)	
2014	2406 (22.0%)	1469 (20.2%)	937 (25.7%)	
2015	2293 (20.5%)	1454 (19.9%)	785 (21.5%)	
2016	1562 (14.3%)	1264 (17.3%)	298 (8.2%)	
2017	1387 (12.7%)	1114 (15.3%)	273 (5.1%)	
Charlson comorbidity index	2 (2–8)	2 (2–8)	2 (2–8)	0.29
Chemotherapy	5100 (46.6%)	2992 (41.0%)	2108 (57.8%)	< 0.001
Radiotherapy	1877 (17.2%)	229 (3.1%)	1648 (45.2%)	< 0.001
Insurance type				0.29
Comprehensive	396 (3.6%)	277 (3.8%)	119 (3.3%)	
EPO	122 (1.1%)	79 (1.1%)	43 (1.2%)	
HMO	1130 (10.3%)	784 (10.8%)	346 (9.5%)	
POS	783 (7.2%)	531 (7.3%)	252 (6.9%)	
PPO	6549 (59.9%)	4313 (59.2%)	2236 (61.3%)	
POS with capitation	103 (0.9%)	71 (1.0%)	32 (0.9%)	
CDHP	1153 (10.5%)	761 (10.4%)	392 (10.8%)	
HDHP	589 (5.4%)	402 (5.5%)	187 (5.1%)	
Missing	110 (1.1%)	71 (0.9%)	39 (1.0%)	
Employment status				0.015
Active full time	6057 (55.4%)	4042 (55.5%)	2015 (55.3%)	
Active part time or seasonal	88 (0.8%)	66 (0.9%)	22 (0.6%)	
Early retiree	1083 (9.9%)	744 (10.2%)	339 (9.3%)	
Medicare eligible retiree	97 (0.9%)	76 (1.0%)	21 (0.6%)	
Retiree (status unknown)	36 (0.3%)	24 (0.3%)	12 (0.3%)	
COBRA continuee	25 (0.2%)	12 (0.2%)	13 (0.2%)	
Long-term disability	60 (0.5%)	38 (0.5%)	22 (0.6%)	
Surviving spouse/depend.	31 (0.3%)	24 (0.3%)	7 (0.2%)	
Other/unknown	3458 (31.6%)	2263 (31.0%)	1195 (32.8%)	
Metropolitan Statistical area	9000 (82.3%)	5985 (82.1%)	3015 (82.7%)	0.45
Region				0.006
Northeast	2010 (18.4%)	1322 (18.1%)	688 (18.9%)	
Midwest	2166 (19.8%)	1482 (20.3%)	684 (18.9%)	
South	5122 (46.8%)	3452 (47.4%)	1670 (45.8%)	
West	1523 (13.9%)	962 (13.2%)	561 (15.4%)	
Unknown	114 (1.0%)	71 (1.0%)	43 (1.2%)	

EPO exclusive provider organization, *HMO* health maintenance organization, *POS* point of service, *PPO* preferred provider organization, *CDHP* consumer directed health plan, *HDHP* high deductible health plan, *COBRA* Consolidated Omnibus Budget Reconciliation Act

US\$321 (IQR US\$106–843) in the perioperative period, US\$446 (IQR US\$100–1187) in the adjuvant period, and US\$409 (IQR US\$114–1060) in the postoperative period. These OOP costs correspond to 6.2% (IQR 1.9–12.9%) of total costs in the preoperative period, 4.4% (IQR 1.7–10.2%) in the perioperative period, 5.2% (IQR

1.2–12.8%) in the adjuvant period, and 4.7% (IQR 1.2–10.5%) in the postoperative period. Analyses stratified by cancer location (colon or rectum) demonstrated similar trends for both colon and rectal cancer patients (Table 3).

TABLE 2 Total and OOP costs for claims associated with outpatient services, inpatient services, chemotherapy, or radiotherapy across the time periods included in the study

Service	Time			
	Preoperative period	Perioperative period	Adjuvant period	Surveillance period
Total	<i>n</i> = 9264	<i>n</i> = 10,454	<i>n</i> = 6188	<i>n</i> = 10,003
Total costs (US\$)	1921 (543–11,336)	44,723 (32,398–65,575)	9647 (1031–24,714)	21,327 (4749–60,591)
OOP (US\$)	432 (130–1452)	2146 (851–3525)	200 (71–640)	969 (327–2239)
OOP/total (%)	17.9 (7.6–36.1)	4.5 (1.7–8.7)	4.0 (1.1–13.8)	5.1 (1.8–14.5)
Outpatient*	<i>n</i> = 631	<i>n</i> = 8133	<i>n</i> = 328	<i>n</i> = 1152
Total costs (US\$)	1815 (539–8880)	9455 (5436–16,859)	7108 (931–20,660)	15,792.5 (4390–46,018)
OOP (US\$)	400 (126–1266)	812 (300–1672)	190 (70–576)	847 (303–1982)
OOP/total (%)	18.4 (8.0–36.7)	9.2 (3.5–17.9)	4.5 (1.2–14.6)	5.9 (2.1–15.4)
Inpatient*	<i>n</i> = 9244	<i>n</i> = 10,254	<i>n</i> = 6155	<i>n</i> = 9980
Total costs (US\$)	19,303 (11,847–38,201)	32,447 (23,443–48,046)	19,311 (11,690–29,893)	27,401 (16,281–48,406)
OOP (US\$)	1300 (480–2453)	1338 (534–2440)	433 (200–1203)	845 (291–2001)
OOP/total (%)	6.4 (2.1–14.2)	4.0 (1.6–8.0)	2.0 (0.9–6.2)	2.5 (0.9–6.8)
Chemotherapy	<i>n</i> = 258	<i>n</i> = 221	<i>n</i> = 823	<i>n</i> = 1627
Total costs (US\$)	1450 (65–22,372)	672 (121–5230)	2281 (813–9950)	4083 (1324–22,433)
OOP (US\$)	71 (16–747)	42 (10–216)	137 (40–547)	205 (53–768)
OOP/total (%)	4.8 (1.2–13.3)	10.0 (2.7–20.0)	7.9 (2.8–18.4)	4.0 (1.4–10.9)
Radiotherapy	<i>n</i> = 603	<i>n</i> = 451	<i>n</i> = 49	<i>n</i> = 104
Total costs (US\$)	7628 (3288–16,205)	5456 (2284–14,951)	7897 (3892–19,522)	7937 (2230–20,870)
OOP (US\$)	374 (140–921)	321 (106–843)	446 (100–1187)	409 (114–1060)
OOP/total (%)	6.2 (1.9–12.9)	4.4 (1.7–10.2)	5.2 (1.2–12.8)	4.7 (1.2–10.5)

Costs calculated only for patients who had at least one claim associated with OOP costs in the period of interest (*n*)

OOP out-of-pocket

*Costs associated with inpatient or outpatient services also include costs associated with chemotherapy and/or radiotherapy

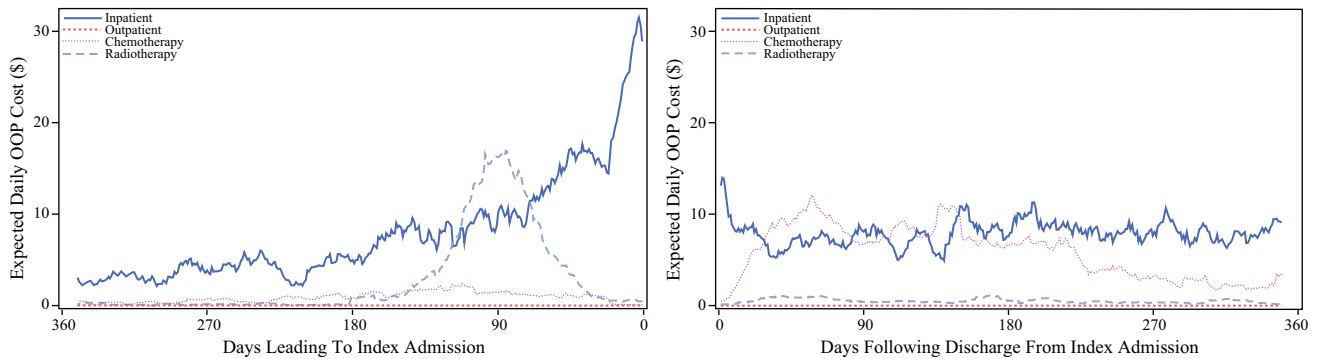


FIG. 1 Fourteen-day moving average of daily OOP costs in the preoperative (left) and postoperative (right) period, by service type

Multivariable Analysis

On multivariable analysis, several patient demographic and clinical characteristics were associated with total OOP costs between 1 year preoperatively and 1 year postoperatively (Table 4). In particular, older age (–US\$9.66, 95% CI –US\$19.10 to –US\$0.21 per 1-year increase) and higher CCI score (+US\$76.41, 95% CI +US\$49.53 to

+US\$103.30 per 1-point increase) were associated with marginal changes in total OOP costs. In contrast, receipt of chemotherapy (+US\$1367.70, 95% CI +US\$1210.58 to +US\$1524.82) and radiotherapy (+US\$842.44, 95% CI +US\$626.24–+US\$1058.64) were both associated with much higher total OOP costs.

Additionally, there was substantial regional variability in total OOP costs. Patients from the Northeast

TABLE 3 Total and OOP costs for claims associated with outpatient services, inpatient services, chemotherapy, or radiotherapy across the time periods included in the study, stratified by cancer type

Services	Time			
	Preoperative period	Perioperative period	Adjuvant period	Surveillance period
<i>Colon cancer (n = 7289)</i>				
Total	n = 6066	n = 7068	n = 4130	n = 6656
Total cost (US\$)	1341 (469–5234)	41,729 (30,625–59,865)	7119 (674–23,099)	16,373 (3877–53,852)
OOP (US\$)	339 (110–1015)	2232 (999–3578)	188 (60–600)	891 (301–2094)
OOP/total (%)	21.0 (9.6–40.7)	5.1 (2.1–9.2)	4.6 (1.2–15.5)	5.9 (2.0–16.3)
Outpatient*	n = 6053	n = 6927	n = 4109	n = 6647
Total cost (US\$)	1290 (463–4483)	8211 (4827–13,655)	5758 (646–20,108)	13,241 (3670–43,124)
OOP (US\$)	320 (105–905)	795 (305–1630)	180 (60–565)	820 (291–1932)
OOP/total (%)	21.6 (10.0–41.7)	10.3 (4.4–19.1)	5.1 (1.4–15.9)	6.6 (2.3–17.1)
Inpatient*	n = 370	n = 5784	n = 166	n = 601
Total cost (US\$)	19,050 (11,407–38,231)	31,522 (22,794–46,549)	18,636 (10,629–32,606)	30,637 (16,148–53,431)
OOP (US\$)	1338 (459–2480)	1399 (586–2473)	306 (171–905)	807 (275–2078)
OOP/total (%)	6.6 (2.2–14.6)	4.2 (1.7–8.3)	1.8 (0.6–4.7)	2.4 (0.8–6.7)
Chemotherapy	n = 89	n = 86	n = 511	n = 1042
Total cost (US\$)	14,923 (1238–40,166)	1586 (353–8149)	2499 (893–10,883)	4508 (1471–24,737)
OOP (US\$)	385 (58–1410)	109 (34–669)	129 (40–544)	219 (61–828)
OOP/total (%)	3.0 (1.0–7.5)	10.0 (2.5–20.0)	7.1 (2.5–17.1)	3.9 (1.4–10.9)
Radiotherapy	n = 14	n = 4	n = 15	n = 45
Total cost (US\$)	7116 (3050–14,927)	1803 (235–8898)	6265 (2925–12,605)	6572 (1328–18,012)
OOP (US\$)	156 (53–514)	568 (308–1769)	478 (75–1038)	360 (90–1343)
OOP/total (%)	1.6 (1.0–5.5)	7.1 (4.9–16.6)	11.4 (1.4–20.0)	4.0 (1.2–14.4)
<i>Rectal cancer (n = 3643)</i>				
Total	n = 3198	n = 3386	n = 2058	n = 3347
Total cost (US\$)	7379 (866–33,328)	52,751 (36,672–76,256)	13,382 (2863–27,852)	32,542 (8435–70,708)
OOP (US\$)	812 (195–2459)	1955 (619–3421)	231 (90–725)	1131 (390–2465)
OOP/total (%)	12.5 (5.3–26.6)	3.5 (1.0–7.3)	2.9 (0.8–10.4)	4.0 (1.6–10.7)
Outpatient*	n = 3191	n = 3327	n = 2046	n = 3333
Total cost (US\$)	6066 (859–29,606)	13,331 (7144–25,550)	9163 (1906–21,815)	19,953 (6735–51,408)
OOP (US\$)	711 (188–2215)	837 (281–1799)	205 (85–604)	911 (339–2090)
OOP/total (%)	12.8 (5.4–27.1)	6.8 (2.2–14.6)	3.6 (1.1–11.4)	4.9 (1.9–12.3)
Inpatient*	n = 261	n = 2349	n = 162	n = 551
Total cost (US\$)	19,426 (12,333–37,971)	34,299 (24,937–50,987)	19,869 (12,476–28,588)	24,636 (16,417–43,646)
OOP (US\$)	1284 (521–2361)	1193 (467–2342)	500 (250–1367)	892 (297–1941)
OOP/total (%)	6.1 (2.0–13.7)	3.4 (1.2–7.1)	2.5 (1.1–8.2)	2.6 (1.0–6.8)
Chemotherapy	n = 169	n = 135	n = 312	n = 585
Total cost (US\$)	360 (42–13,865)	284 (60–2965)	1884 (719–8260)	3392 (1156–19,086)
OOP (US\$)	36 (7–418)	26 (6–115)	152 (41–614)	186 (45–708)
OOP/total (%)	6.5 (1.6–16.0)	10.0 (2.8–20.0)	9.4 (3.3–20.0)	4.2 (1.5–10.8)
Radiotherapy	n = 589	n = 447	n = 34	n = 59
Total cost (US\$)	7666 (3327–16,205)	5626 (2364–15,078)	8913 (4111–20,566)	8936 (2943–23,145)
OOP (US\$)	380 (144–949)	318 (106–843)	443 (100–1211)	468 (158–1060)
OOP/total (%)	6.3 (2.0–13.0)	4.4 (1.7–10.2)	4.3 (1.1–10.0)	5.2 (1.4–9.9)

Costs calculated only for patients who had at least one claim associated with out-of-pocket costs in the period of interest (n)

OOP out-of-pocket

*Costs associated with inpatient or outpatient services also include costs associated with chemotherapy and/or radiotherapy

TABLE 4 Results of multivariable linear regression showing the difference in US\$ in OOP costs over the entire study period for the comparison group versus the reference group

Effect	Comparison	Reference	Difference (US\$)	95% CI (US\$)	p-Value
Age	1-year increase		− 9.66	− 19.10 to − 0.21	0.04
CCI	1-point increase		+76.41	+49.53 to +103.30	< 0.001
Sex	Male	Female	− 109.95	− 244.83 to +24.94	0.11
Region	Northeast	South	− 1350.96	− 1537.88 to − 1164.04	< 0.001
	Midwest		− 605.27	− 787.74 to − 422.79	< 0.001
	West		− 453.04	− 660.86 to − 245.21	< 0.001
	Active part time or seasonal		+578.45	− 169.55 to +1326.44	0.13
	Early retiree		− 535.72	− 784.70 to − 286.74	< 0.001
	Medicare eligible retiree		− 1108.20	− 1846.65 to − 369.75	0.003
	Employment status	Retiree (status unknown)	Active full time	+724.68	− 441.27 to +1890− 63
COBRA continuee			+1705.62	+311.0 to +3100.24	0.02
Long-term disability			+14.40	− 904.63 to +933.43	0.98
Surviving spouse/depend.			− 495.28	− 1779.68 to +789.12	0.45
Cancer type	Rectal	Colon	+50.05	− 117.10 to +217.20	0.56
Chemotherapy	Yes	No	+1367.70	+1210.58 to +1524.82	< 0.001
Radiotherapy	Yes	No	+842.44	+626.24 to +1058.64	< 0.001
MSA	Yes	No	+104.29	− 77.77 to +286.34	0.26
Insurance type	EPO		− 1598.89	− 2334.89 to − 862.89	< 0.001
	HMO		− 2119.09	− 2549.65 to − 1688.54	< 0.001
	POS		− 938.09	− 1385.18 to − 491.0	< 0.001
	PPO		+361.68	− 22.78 to +746.15	0.07
	POS with capitation	Comprehensive	− 2130.76	− 2921.02 to − 1340.51	< 0.001
	CDHP		+1399.67	+972.04 to +1827.30	< 0.001
	HDHP		+3242.58	+2767.43 to +3717.72	< 0.001

CCI Charlson Comorbidity Index, COBRA Consolidated Omnibus Budget Reconciliation Act, MSA Metropolitan Statistical Area, EPO exclusive provider organization, HMO health maintenance organization, POS point of service, PPO preferred provider organization, CDHP consumer directed health plan, HDHP high deductible health plan

(−US\$1350.96, 95% CI −US\$1537.88 to −US\$1164.04), the Midwest (−US\$605.27, 95% CI −US\$787.74 to −US\$422.79), or West (−US\$453.04, 95% CI −US\$660.86 to −US\$245.21) all incurred considerably lower total OOP costs compared with patients from the South. Employment status was also associated with overall OOP costs, with early retirees and Medicare eligible retirees facing lower total OOP costs than full-time employees (−US\$535.72, 95% CI −US\$784.70 to −US\$286.74 and −US\$1108.20, 95% CI −US\$1846.65 to −US\$369.75, respectively). In contrast, COBRA continuees incurred substantially higher total OOP costs than full-time employees (+US\$1705.62, 95% CI +US\$311.0 to +US\$3100.24). In addition, health insurance plan type was associated with total OOP costs. Specifically, patients with an EPO (−US\$1598.89, 95% CI −US\$2334.89 to −US\$862.89), an HMO (−US\$2119.09, 95% CI −US\$2549.65 to −US\$1688.54) or a POS plan (−US\$938.09, 95% CI −US\$1385.18 to −US\$491.0) had

lower total OOP costs than patients with a comprehensive health insurance plan. Conversely, patients with a CDHP or an HDHP plan had considerably higher total OOP costs compared with patients with a comprehensive health insurance plan (+US\$1399.67\$, 95% CI +US\$972.04 to +US\$1827.30 and +US\$3242.58, 95% CI +US\$2767.43 to +US\$3717.72).

DISCUSSION

Curative treatment of colorectal cancer requires a multidisciplinary approach that involves a combination of surgery, chemotherapy, and/or radiotherapy, leading to high treatment costs.^{28,29} In recent years, insurers have attempted to counteract the rising costs of cancer care by shifting a greater proportion of these costs to the patient through deductibles, copayments, and coinsurance.³⁰ As a result, even insured colorectal cancer survivors often face significant financial hardship due to the direct and indirect

costs of their treatment.^{19,31,32} As financial hardship is associated with worse outcomes for cancer patients, it is of utmost importance that patient–provider discussions on cancer treatment also include a discussion of the OOP costs associated with each treatment option.³³ Existing evidence suggests that cancer patients would be comfortable with and open to such discussions.³⁴ Despite this, patient–provider cost communication only rarely occurs in clinical practice.³⁵ In the case of colorectal cancer patients, one obstacle to having meaningful and impactful patient–provider discussions on treatment costs is the lack of reliable estimates of OOP costs associated with curative treatment. Therefore, the current study is important because we assessed OOP costs between 1 year preoperatively and 1 year postoperatively in a large cohort of commercially insured colorectal cancer patients undergoing surgical resection. We found that patients pay a median of US\$4417 in OOP costs over this period, or 4.5% of total costs. While OOP costs represented a lower proportion of total costs in the postoperative period, they were still significantly higher than the costs in the preoperative period. In addition, OOP costs varied widely relative to receipt of chemotherapy or radiotherapy, region of residence, employment status, and insurance plan type.

The main finding of the current study was that privately insured patients who underwent surgical resection for colorectal carcinoma spent a median of US\$4417 in OOP costs between 1 year preoperatively and 1 year postoperatively. Somewhat unsurprisingly, OOP costs spiked in the perioperative period and gradually decreased in the postoperative period. However, postoperative OOP costs never returned to their preoperative levels (Table 2; Fig. 1). These findings are in line with a previous study by Dieguez et al., who noted a similar pattern of OOP spending among commercially insured colorectal cancer patients diagnosed in 2011.²¹ Specifically, Dieguez et al. reported that, following an initial peak associated with treatment, OOP costs did not return to baseline for as long as 3 years after the initial cancer diagnosis. Of note, the bulk of OOP costs over the study period was associated with inpatient services, while costs associated with outpatient services only represented a minor share of all OOP costs (Fig. 1). In a 2017 analysis of 1409 Medicare beneficiaries diagnosed with cancer, Narang et al. similarly reported that inpatient services accounted for a vast majority of total OOP costs.³⁶ The current analysis was the first to note that radiotherapy and chemotherapy were also associated with meaningful OOP costs in the preoperative and postoperative period, respectively (Fig. 1). On multivariable analysis, receipt of chemotherapy and radiotherapy were both associated with a drastic increase in total OOP costs over the study period (Table 4). Since patients of lower socioeconomic status tend to place a disproportionate importance on costs when

making treatment decisions, the OOP costs associated with radiotherapy and chemotherapy may be contributing to existing disparities in receipt of these treatment modalities for colorectal cancer treatment.^{37–39}

Of note, several patient demographic and clinical characteristics were associated with OOP costs on multivariable analysis (Table 4). Specifically, older age was associated with a decrease in OOP costs, albeit a minor one. Previous studies had noted that younger cancer patients were particularly vulnerable to financial hardship following a cancer diagnosis.^{7,40} Results of the current study suggested that the financial impact of surgical treatment associated with colorectal cancer treatment among younger patients was mainly mediated by differences in employment and health insurance status, rather than by younger age itself. In particular, COBRA continuees faced higher OOP costs than full-time employees, who in turn incurred higher OOP costs than early retirees and Medicare eligible retirees. Additionally, there was a notable yet nonsignificant trend for higher OOP costs among part-time employees compared with full-time employees (Table 4). Colorectal cancer and its treatment are known to severely limit patient ability to work, resulting in lost wages and income, as well as disruptions in health insurance coverage.^{41,42} Results of the current study suggest that patients who are in less stable positions and are more prone to such disruptions face higher OOP costs when undergoing surgical treatment of colorectal cancer. Nevertheless, the single most important factor determining the amount of OOP costs incurred by colorectal cancer patients undergoing resection was their health insurance plan type. Notably, postoperative OOP costs accounted for a smaller proportion of overall costs than preoperative OOP costs (Table 2). As such, healthcare insurance was mostly effective at mitigating the financial impact of the surgical treatment of colorectal cancer. However, the amount of OOP costs paid by patients varied widely based on the specific insurance plan type. Specifically, patients with a CDHP or HDHP paid as much as US\$1400 and US\$3242 more, respectively, than patients with a comprehensive plan, who in turn paid US\$2119 more than patients with an HMO plan (Table 4). Of note, HDHPs have recently grown in popularity, and as many as 51% of all US workers were enrolled in one in 2019.⁴³ As such, OOP costs associated with the surgical treatment of colorectal cancer can be expected to have an increasingly large impact on a growing number of patients.

Findings from the current study may inform initiatives aimed at mitigating the financial impact of surgical treatment of colorectal cancer patients. Specifically, the fact that OOP costs remain elevated well beyond the initial spike associated with surgical treatment suggested that patient–provider cost discussions should not stop at the

treatment selection phase, but should also include the long-term financial repercussions of treatment (Fig. 1). Additionally, the type of health insurance plan in which colorectal cancer patients were enrolled was the single most important factor in determining the amount of OOP costs incurred, as had been similarly reported relative to other cancer patient populations (Table 4).^{44,45} As such, colorectal cancer patients should be counseled about the options available to switch to a more favorable health insurance plan during the next available open enrollment period. Should patients decide to remain enrolled in a HDHP, the high deductibles associated with such plans may be at least partially offset by participation in a health savings account (HSA). Of note, however, significant race- and income-based disparities exist in HSA participation, to the point that not all patients may be able to benefit from the financial protection a HSA offers.⁴⁶ Several factors other than treatment options have an impact on OOP costs associated with cancer care, including the setting in which the treatment is provided and the involvement of out-of-network providers at in-network hospitals.^{2,47,48} Transparency in patient-provider cost discussions about such factors would greatly limit their impact on the OOP costs associated with surgical treatment of colorectal cancer.

Several limitations should be considered when interpreting the results of the current study. The IBM MarketScan commercial database is based on a large, nonrandom convenience sample that may lead to a sample bias (i.e., the South portion of the USA overrepresented), leading to lack of generalizability.⁴⁹ As with all studies relying on administrative databases, only variables associated with specific ICD or CPT codes could be examined. As such, no information on tumor stage or guideline-concordant care was available. This shortcoming is particularly relevant because associations between factors such as region of residence and OOP costs may be at least in part explained by differences in tumor stage at presentation. Additionally, the current study only included commercially insured individuals, who represent approximately two-thirds of the US population.⁵⁰ As such, results of the current study cannot be extrapolated to patients who are insured through a public plan or are uninsured. Moreover, information on monthly premiums paid by patients was not available. Since premiums represent a portion of OOP costs for commercially insured individuals and differ based on plan type, we were limited in our ability to assess the financial OOP burden associated with each plan type. Of note, the current study only considered direct OOP costs associated with cancer treatment. However, indirect costs associated with transportation or lost income may be equally as impactful on patient finances.⁵¹ Lastly, patients included in the current study underwent surgery between 2013 and 2017. The ongoing coronavirus disease 2019

(COVID-19) pandemic is likely to have had a large impact on the costs of cancer care by means of delayed or skipped cancer screening, postponed or missed cancer treatment, and insurance coverage disruptions.^{52,53} The current study could not capture these recent changes.

In conclusion, privately insured patients who underwent surgical resection of colorectal cancer paid a median of US\$4417 in OOP costs within 1 year prior and 1 year after surgery, which corresponded to 4.5% of total costs. Notably, OOP costs varied widely with receipt of chemotherapy or radiotherapy, region of residence, employment status, and health insurance plan type. By providing estimates of excess OOP costs associated with several patient- and treatment-level factors, results of the current study may inform patient-provider discussions on treatment preferences. Specifically, these data may assist patients in assessing the cost-benefit ratio of various treatment options, plan around the expenses associated with cancer care, and be promptly referred to financial navigation services if difficulties with payments are expected. The data highlight the need for policies to ensure that OOP costs do not dissuade cancer patients from seeking optimal care.

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DISCLOSURES The authors declare no conflicts of interest.

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