ORIGINAL RESEARCH

Net costs of breast cancer care in a health promotion entity of Colombia

Costos netos de la atención del cáncer de mama en una entidad promotora de salud en Colombia

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Abstract

Introduction: The estimation of costs associated with cancer care is essential for the implementation of technologies, programs, and policies aimed at prevention and treatment.

Objective: To estimate the average annual net costs of breast cancer care for each phase of care and the average annual net cost per patient in each phase of care of patients under the contributory regime subscribed to a health promotion entity (EPS by its Spanish acronym) in Colombia.

Material and methods. Retrospective matched case-control study conducted using data from 4 278 patients served between January 1, 2010, and December 31, 2016, by an EPS with a presence throughout Colombia (713 cases with breast cancer and 3 565 controls). Net costs were estimated utilizing the net cost method and were expressed in constant 2023 US dollars for each phase of care (initial, continuing, and last year of life).

Results: The average annual net costs of breast cancer care for the initial, continuing, and last year of life phases were 24 431 719.80 USD, 27 325 443.38 USD, and 6 786 347.62 USD, respectively. The average annual net costs per patient for these same phases were 50 583.27 USD, 46 710.16 USD, and 147 529.30 USD, respectively.

Conclusion: The average annual net costs of breast cancer care were higher in the continuing phase, followed by the initial and last year of life phases. In turn, the average annual net cost per patient was higher in the last year of life phase, followed by the initial phase.

Resumen

Introducción. La estimación de costos de atención es fundamental para implementar tecnologías, programas y políticas en prevención y atención del cáncer.

Objetivo. Estimar los costos netos anuales promedio de atención del cáncer de mama por fase de atención y el costo neto anual promedio por paciente en cada fase de atención en pacientes afiliados a una entidad promotora de salud - EPS (régimen contributivo) de Colombia.

Materiales y métodos. Estudio de casos y controles pareado retrospectivo realizado con datos de 4 278 pacientes atendidas entre enero 1 de 2010 y diciembre 31 de 2016 en una EPS con presencia en toda Colombia (713 casos con cáncer de mama y 3 565 controles). Los costos netos se estimaron utilizando el método de costo neto y fueron expresados en dólares americanos constantes 2023 para cada fase de atención (inicial, continua y último año de vida).

Resultados. Los costos netos anuales promedio de atención del cáncer de mama para las fases inicial, continua y último año de vida fueron 24 431 719.80 USD, 27 325 443.38 USD y 6 786 347.62 USD, respectivamente, y los costos netos anuales promedio por paciente para estas mismas fases fueron de 50 583.27 USD, 46 710.16 USD y 147 529.30 USD.

Conclusión. Los costos netos anuales promedio de la atención del cáncer de mama fueron más altos en la fase continua, seguida de las fases inicial y último año de vida. Por su parte, el costo neto anual promedio por paciente fue más alto en la fase último año de vida, seguida por la fase inicial.

Introduction

In 2022, 19 976 499 new cancer cases were reported worldwide, with lung cancer being the most common, followed by breast cancer (12.4 and 11.5%). That same year, 117 620 new cases of cancer were reported in Colombia, and breast cancer was the most frequent malignant neoplasm with 17 018 cases (14.5%).[1]

Direct medical costs of breast cancer care have been the subject of study by several researchers. For example, Schneider *et al.*,[2] in a study including data from 597 patients with advanced breast cancer diagnosed between 2010 and 2014 in the Netherlands, found that the average cost per patient was 52 709 EUR, with 56% attributed to the use of systemic therapies and 20% to hospital stay. In turn, Montiel *et al.*,[3] in a study conducted with 60 patients to analyze the direct costs of early and advanced stage breast cancer care at the Mexican Social Security Institute, reported that the average cost per patient was 5 230.78 USD and 7 789.92 USD for the early and advanced stages, respectively, and that this difference stemmed from the fact that patients in the advanced stage require more laboratory studies, surgeries and cross-consultations, and that their hospital stay is longer.

In Colombia, cost estimation studies of breast cancer care are limited. Moreno *et al.*[4] reported that the average annual cost of medical care provided to 1 314 breast cancer patients between 2010 and 2014 was 5 709 078.15 USD, with average annual costs per patient between 5 214.47 USD and 8 350.95 USD; Gamboa *et al.*[5] reported that the total cost of care in 2012 for metastatic breast cancer was 144 400 865 COP (81 664.07 USD) and 65 603 537 COP (37 101.25 USD) for regional breast cancer; Torres *et al.*[6] estimated that the total net costs of breast cancer care being covered by the contributory regimen in 2019 for 46 148 patients was 387 000 000 USD and indicated that 60% of that amount was not associated with the basic health plan (BHP); and Gamboa *et al.*[7] reported an increase in breast cancer care costs as the number of care providers increased during the first year after diagnosis.

Other studies have addressed methods for estimating cancer care costs. For example, Lipscomb *et al.*[8] and Barlow *et al.*[9] report that there is heterogeneity in cancer cost estimation in terms of the methodologies used to obtain and study the data, the way costs are measured, and the populations studied. This heterogeneity generates difficulties for comparing costs across published studies worldwide, and breast cancer is no exception. Along the same lines, Francisci *et al.*[10] conducted a study to illustrate a new comprehensive approach (Epicost) for estimating the economic burden of cancer and described several methods for estimating cancer care costs, showing advantages and disadvantages in the implementation of each of them. Finally, Blayney *et al.*,[11] in a study in which they developed a method to measure the cost of three phases of care for breast cancer patients (initial treatment with curative intent, surveillance and survivorship care, and relapse and end-of-life care), they demonstrated that it is possible to take data from multiple sources and health care systems and estimate a normalized cost across systems.

The objective of the present study was to estimate the average annual net costs of breast cancer care by phase of care and the average annual net cost per patient in each phase of care of patients under the contributory regime subscribed to a health promotion entity (EPS by its Spanish acronym) in Colombia, using the phases of care as an estimator of the additional burden from the perspective of a third-party payer.[12-14]

Materials and methods

Study type

Retrospective matched case-control study.

Study population and sample

The study population comprised women over 18 years of age treated between January 1, 2010, and December 31, 2016, by an EPS with a presence across the country through health service provider institutions that are part of its health care network. A total of 4 278 patients were included (713 cases and 3 565 controls, case-control ratio of 1:5). Cases were defined as patients with primary breast cancer with no other type of cancer who survived at least 30 days after diagnosis, while controls were defined as women over 18 years of age with no cancer diagnosis (any type) before or after the analysis period who used the health system in the year prior to the date of pseudodiagnosis.[15,16]

Cases and controls were matched by age at diagnosis, geographic location, and phase of care using the Coarsened Exact Matching (CEM) program.[17,18]

Source of information

Data were obtained from the individual records of direct patient care provided by the EPS, an institution that as of December 2016 had 2 545 742 subscribers, of which 96% pertained to the contributory regime and accounted for 5.4% of the total Colombian population for that year.[19]

Cases were grouped by type of breast cancer (International Classification of Diseases - ICD-10[20]), place of residence (department), age at diagnosis, and cancer stage. Cost was estimated based on individual records of activities, procedures and interventions, from which the resources spent on breast cancer care (i.e., drugs, diagnostic and treatment procedures, surgeries, medical devices, consultations, and imaging and laboratory tests) were identified, quantified, and appraised.

Estimated annual net costs of breast cancer care

Phase of care was defined based on previous studies of the direct costs of cancer care as follows:[12,21,22] initial phase (12 months after the date of diagnosis), last year of life phase (12 months before the date of death), and continuing phase (time elapsed between the last year of life phase and the initial phase). For patients who survived less than 24 months after diagnosis, the last 12 months of survival were assigned to the last year of life phase and the remaining months to the initial phase.[13,15,23] Moreover, patients diagnosed before 2010 and still alive after 2016 contributed 84 months to the continuing phase during the study period (2010-2016), while those who survived 12 months or less after diagnosis were assigned to the last year of life phase.

The net cost method was used to make an estimate of the specific incremental costs of direct medical care for breast cancer. This case-control approach to estimating cancer-specific costs is commonly accepted as a method for estimating the difference between the costs of health care provided to a patient with cancer and the costs of health care provided to a patient without cancer.[16]

The average annual net cost per phase of care was defined as:

$$CNAPphase = \sum_{i=1}^{7} \frac{Cost\ cases\ per\ phase}{N} - \sum_{i=1}^{7} \frac{Cost\ cases\ per\ phase}{N}$$

Where:
CNAPphase: average annual net cost of care phase.
N: number of years per phase of care.

The average annual net cost per patient per phase was defined as:

$$CNAPphase = \sum_{i=1}^{7} \frac{CN\ Aphase\ cases}{n} - \sum_{i=1}^{7} \frac{CN\ Aphase\ controls}{n}$$

Where:
CNAPPphase: average annual net cost of care phase.
n: number of patients per phase of care.

Considering that the study population was large enough, the statistical methods for cost analysis were based on the central limit theorem, in which both the mean of the estimated costs for each phase of care and the mean of the costs per patient in each phase of care, as well as the corresponding confidence intervals for each of these values, were assumed to be under a normal distribution.[13,15] All analyses were performed in the R software version 4.4.1.[24]

Furthermore, since there was no diagnosis date for the controls, a pseudodiagnosis date was established using the diagnosis date of the case with which the matching was done. To maximize statistical power, several controls were assigned to one case in each of the phases.[25-27]

The time frame for obtaining health care resource utilization costs was established from January 1, 2010, to December 31, 2016. Resource estimates were derived from different time periods and, using the health care-specific inflation rate, a monthly inflation adjustment was made during the study period based on the following mathematical expression:[28]

$$V_{pres} = \sum_{i=1}^{84} \frac{V_{pas}CPI_{pres}}{CPI_{pas}}$$

Where:
Vpres: present value of the cost of resource usage as of December 2023.
Vpas: value reported by the database on the day, month, and year of care.
CPIpres: consumer price index (CPI) in the health sector as of December 2023.
CPIpas: consumer price index for the month in which the service was provided.

The average annual net costs of breast cancer care by phase of care and the average annual net cost per patient in each phase of care for activities, procedures, and interventions related to direct breast cancer care were estimated, adjusted, and expressed in constant 2023 USD. No direct non-medical costs (transportation costs, travel time, waiting and consultation time, care costs) or indirect costs (lost productivity) were estimated.[29]

Ethical considerations

Although the study was carried out using secondary data, it should be noted that data confidentiality and patient anonymity were guaranteed at all times.

Results

The most prevalent type of cancer was malignant neoplasm of the breast when the site is unspecified (ICD-10: C50.9; 70.27%, n=501), followed by malignant neoplasm in the upper-outer quadrant of the breast (ICD-10: C50.4; 19.35%, n=138). Regarding place of residence, it was found that 24.96% (n=178), 12.76% (n=91), and 9.96% (n=71) of the patients lived in Bogotá D.C., Antioquia, and Atlántico, respectively (Table 1).

The mean age at diagnosis was 61 years (±11.22). Data on cancer stage at diagnosis were available in only 65.22% of cases (n=465), with stage IIA (23.23%; n=108) and IIIB (16.34%; n=76) being the most frequent. Moreover, 18.49% of these patients were between 55 and 59 years old at the time of diagnosis, this being the most frequent age group (Table 2).

Table 1. Distribution of cases by type of breast cancer and place of residence (n=713).

Place of residence	C50.0 *	C50.1 *	C50.2 *	C50.3 *	C50.4 *	C50.5 *	C50.9 *	D05.1 *	D05.7 *	D05.9 *	Total	%
Bogotá D.C.		2			38		138				178	24.96
Antioquia					1		85			5	91	12.76
Atlántico					8	2	57			4	71	9.96
Caldas			3	1	31	5	21			2	63	8.84
Santander		1	4	3	14		33	1		5	61	8.56
Risaralda			1	4	8	3	32				48	6.73
Tolima			1		4	1	42				48	6.73
Bolívar		5	3	4	14	1	17			1	45	6.31
Valle del Cauca	1		2	1	11	2	21		1		39	5.47
Cundinamarca			1		4		14			1	20	2.81
Magdalena					1		15				16	2.24
Cesar			2		2		10			1	15	2.10
Meta					2		4				6	0.84
Sucre							6				6	0.84
Córdoba							5				5	0.70
Quindío							1				1	0.14
Total	1	8	17	13	138	14	501	1	1	19	713	100.00
%	0.14	1.12	2.38	1.82	19.35	1.96	70.27	0.14	0.14	2.66	100.00	

* Diagnosis according to the International Classification of Diseases (ICD-10).

Table 2. Breast cancer stage by age group (n=465)*.

Age group (age at diagnosis)	Breast cancer stage													
	I	IA	IB	II	IIA	IIB	III	IIIA	IIIB	IIIC	IV	In situ	n (%)	(%)
25-29 years old	0	0	0	0	0	0	0	1	0	0	0	0	1	0.22
30-34 years old	1	0	0	0	1	0	0	0	0	0	0	0	2	0.43
35-39 years old	0	0	0	0	2	2	0	2	0	0	0	1	7	1.51
40-44 years old	0	1	0	1	4	4	0	0	5	0	1	0	16	3.44
45-49 years old	5	2	2	2	4	9	1	6	8	2	3	4	48	10.32
50-54 years old	3	1	3	1	15	18	1	9	15	0	2	2	70	15.05
55-59 years old	9	5	12	3	20	7	0	7	14	0	3	6	86	18.49
60-64 years old	9	3	3	2	17	12	4	7	14	2	1	3	77	16.56
65-69 years old	11	3	3	2	18	6	0	3	4	0	1	4	55	11.83
70-74 years old	2	1	5	2	10	10	2	5	6	0	3	2	48	10.32
75-79 years old	4	3	2	1	9	2	1	2	4	0	0	0	28	6.02
≥80 years old	1	2	1	0	8	2	0	3	6	0	4	0	27	5.81
n	45	21	31	14	108	72	9	45	76	4	18	22	465	100
(%)	9.68	4.52	6.67	3.01	23.23	15.48	1.94	9.68	16.34	0.86	3.87	4.73	100	

* Non-staged patients are excluded.

Tables 3, 4, and 5 present the average annual net costs of breast cancer care and the average annual net costs per patient for the resource groups derived from activities, procedures, and interventions related to breast cancer care at each phase of care. Drugs and diagnostic and treatment procedures accounted for more than 60% of the average annual net cost of breast cancer care by stage across all phases of care (78.33% initial phase, 68.83% continuing phase, and 82.64% last year of life). In contrast, imaging tests accounted for the smallest proportion of average annual net costs in all phases, particularly ultrasound.

In all phases of care, costs were identified for inpatient surgery, medical devices, consultations with specialists, and clinical laboratories, with inpatient surgery having the highest average annual net costs per phase. On the other hand, costs were reported for outpatient surgery, magnetic resonance imaging, and computed tomography in the three phases of care, with a gradual increase between phases (Tables 3, 4, and 5).

With regard to the average annual net cost of breast cancer care, it rose from 24 431 719.80 USD in the initial phase to 27 325 443.38 USD in the continuing phase. However, it decreased to 6 786 347.62 USD in the last year of life phase, which is anticipated given that the number of patients in the last phase of care was considerably lower than in the first two phases (Tables 3, 4, and 5).

Finally, the average annual net costs per patient for each phase of care were 50 583.27 USD, 27 325 443.38 USD and 147 529.30 USD for the initial, continuing, and last year of life phases (Tables 3, 4, and 5).

Table 3. Average annual net cost of breast cancer care and average annual net cost per patient in the initial phase of care in a health promotion entity in Colombia (n=483).

Cost-generating event	No. of cancer patients	Average annual net cost in USD per phase	Lower 95%CI	Upper 95%CI	Average annual net patient cost in USD	Lower 95%CI	Upper 95%CI
Total	483	$24 431 719.80	$24 113 698.24	$24 749 741.36	$50 583.27	$43 894.02	$57 272.53
Drugs	411	$11 946 205.63	$11 657 712.02	$12 234 699.25	$29 066.19	$22 429.75	$35 702.64
Diagnostic and treatment procedures	437	$7 191 092.92	$7 166 431.49	$7 215 754.36	$16 455.59	$14 545.11	$18 366.07
Inpatient surgery	165	$1 278 312.49	$1 269 866.92	$1 286 758.06	$7 747.35	$6 314.52	$9 180.17
Medical devices	268	$673 554.07	$672 168.94	$674 939.19	$2 513.26	$2 000.85	$3 025.67
Specialized medical consultation	471	$561 072.63	$561 018.76	$561 126.50	$1 191.24	$1 103.93	$1 278.54
Clinical laboratory	461	$524 903.53	$524 667.09	$525 139.97	$1 138.62	$954.25	$1 322.99
Outpatient surgery	127	$379 639.13	$378 713.61	$380 564.65	$2 989.28	$2 481.88	$3 496.68
Hospital stay	209	$250 277.89	$249 494.70	$251 061.07	$1 197.50	$786.59	$1 608.41
X-ray	413	$221 061.41	$221 046.27	$221 076.55	$535.26	$488.28	$582.24
Ultrasound	361	$201 454.05	$201 418.42	$201 489.67	$558.04	$482.07	$634.02
Nuclear medicine	192	$182 643.66	$182 601.47	$182 685.84	$951.27	$853.77	$1 048.77
Hospitalization service	60	$150 741.02	$143 940.90	$157 541.14	$2 512.35	$834.34	$4 190.36
Biopsies	118	$148 269.51	$148 142.05	$148 396.97	$1 256.52	$1 064.82	$1 448.23
Computed tomography	93	$126 674.06	$126 514.53	$126 833.58	$1 362.09	$1 134.31	$1 589.87
Magnetic resonance imaging	47	$121 547.73	$120 340.50	$122 754.97	$2 586.12	$1 830.14	$3 342.10
Endoscopy	46	$86 660.84	$78 286.68	$95 035.01	$1 883.93	$119.09	$3 886.96
General practitioner consultation	395	$83 821.15	$83 805.67	$83 836.63	$212.21	$164.25	$260.16
Counseling	360	$65 990.59	$65 988.97	$65 992.21	$183.31	$169.32	$197.29
Emergency consultation	139	$43 363.04	$43 342.16	$43 383.92	$311.96	$238.99	$384.93
Social work	215	$39 932.21	$39 919.62	$39 944.80	$185.73	$135.17	$236.30
Dentistry	100	$33 185.35	$33 148.43	$33 222.27	$331.85	$222.93	$440.78
Outpatient oxygen	8	$25 772.12	$21 486.25	$30 058.0	$3 221.52	$616.95	$5 826.08

USD: constant U.S. dollars 2023.

Table 4. Average annual net cost of breast cancer care and average annual net cost per patient in the continuing phase of care in a Colombian health promotion entity (n=585).

Cost-generating event	No. of cancer patients	Average annual net cost in USD per phase	Lower 95%CI	Upper 95%CI	Average annual net patient cost in USD	Lower 95%CI	Upper 95%CI
Total	585	$27 325 443.38	$27 066 737.56	$27 584 149.21	$46 710.16	$40 995.0	$52 492.12
Drugs	556	$14 230 578.86	$14 026 876.55	$14 434 281.17	$25 594.57	$20 427.76	$30 761.37
Diagnostic and treatment procedures	562	$4 577 129.99	$4 568 342.33	$4 585 917.65	$8 144.36	$7 074.14	$9 214.58
Inpatient surgery	183	$1 865 609.71	$1 852 370.54	$1 878 848.88	$10 194.59	$8 447.75	$11 941.42
Outpatient surgery	210	$948 969.07	$943 629.36	$954 308.77	$4 518.90	$3 447.88	$5 589.93
Medical devices	434	$757 655.53	$754 976.48	$760 334.58	$1 745.75	$1 114.92	$2 376.58
Specialized medical consultation	580	$683 736.53	$683 682.87	$683 790.18	$1 178.86	$1 095.40	$1 262.32
Clinical laboratory	576	$509 395.20	$509 347.77	$509 442.63	$884.37	$805.86	$962.88
Hospital stay	294	$475 700.59	$474 629.34	$476 771.84	$1 618.03	$1 177.67	$2 058.39
Medical care package	36	$465 831.40	$453 601.41	$478 061.38	$12 939.76	$10 346.11	$15 533.41
Magnetic resonance imaging	146	$359 809.93	$359 415.25	$360 204.61	$2 464.45	$2 144.91	$2 784.0
Computerized tomography	248	$344 078.81	$343 998.71	$344 158.92	$1 387.41	$1 261.39	$1 513.44
Nuclear medicine	283	$300 648.15	$300 485.37	$300 810.92	$1 062.36	$888.67	$1 236.05
X-rays	556	$278 074.02	$278 070.10	$278 077.93	$500.13	$477.50	$522.77
Endoscopy	170	$237 508.68	$236 486.91	$238 530.45	$1 397.11	$902.64	$1 891.58
Ultrasound	503	$194 343.81	$194 341.07	$194 346.56	$386.37	$364.80	$407.94
General practitioner consultation	525	$151 603.20	$151 569.63	$151 636.77	$288.77	$222.06	$355.47
Biopsies	109	$150 728.28	$149 900.18	$151 556.38	$1 382.83	$883.36	$1 882.30
Hospitalization service	130	$133 817.75	$132 819.32	$134 816.18	$1 029.37	$505.71	$1 553.02
Social work	449	$91 879.03	$91 873.22	$91 884.83	$204.63	$175.35	$233.91
Home care	25	$82 466.67	$78 866.90	$86 066.44	$3 298.67	$1 731.79	$4 865.55
Patient transportation	57	$53 910.42	$53 274.69	$54 546.16	$945.80	$424.77	$1 466.83
Specialized dental consultation	226	$70 057.99	$70 045.71	$70 070.27	$309.99	$259.38	$360.60
Emergency consultation	302	$63 923.02	$63 919.48	$63 926.56	$211.67	$188.22	$ 235.11
Outpatient oxygen care	12	$27 113.72	$24 564.66	$29 662.78	$2 259.48	$570.13	$ 3 948.82

USD: constant U.S. dollars 2023.

Table 5. Average annual net cost of breast cancer care and average annual net cost per patient in the last year of care in a Colombian health promotion entity (n=46).

Cost-generating event	No. of cancer patients	Average annual net cost in USD per phase	Lower 95%CI	Upper 95%CI	Average annual net patient cost in USD	Lower 95%CI	Upper 95%CI
Total	46	$6 786 347.62	$1 275 243.20	$12 297 452.20	$147 529.30	$95 794.12	$199 264.47
Drugs	44	$4 489 749.91	$821 827.14	$9 801 326.95	$102 039.77	$50 616.17	$153 463.37
Diagnostic procedures and treatment	43	$1 118 345.37	$951 935.15	$1 284 755.58	$26 008.03	$16 847.23	$35 168.84
Hospital stay	28	$193 371.62	$179 772.42	$206 970.81	$6 906.13	$3 942.24	$9 870.02
Inpatient surgery	9	$170 402.61	$4 470.76	$345 275.97	$18 933.62	$3 068.87	$34 798.37
Medical devices	39	$150 307.68	$145 452.80	$155 162.56	$3 854.04	$2 246.05	$5 462.04
Clinical laboratory	42	$101 254.07	$100 431.04	$102 077.10	$2 410.81	$1 763.21	$3 058.41
Specialized medical consultation	46	$71 948.85	$71 507.34	$72 390.36	$1 564.11	$1 102.25	$2 025.97
Medical care package	4	$57 919.80	$57 613.43	$61 226.16	$14 479.95	$10 791.89	$18 168.01
Computed Tomography	26	$52 788.73	$52 042.42	$53 535.04	$2 030.34	$1 320.12	$2 740.55
Endoscopy	8	$45 015.52	$29 940.14	$60 090.90	$5 626.94	$707,73	$10 546.15
Magnetic resonance imaging	13	$40 249.71	$37 109.35	$43 390.07	$3 096.13	$1 262.61	$4 929.65
General practitioner consultation	23	$30 479.72	$29 309.00	$31 650.44	$1 325.21	$401.03	$2 249.38
Nuclear medicine	14	$29 657.55	$26 122.89	$33 192.20	$2 118.40	$226.08	$4 010.71
X-rays	37	$20 690.20	$20 644.05	$20 736.36	$559.19	$396.36	$722.03
Outpatient surgery	8	$18 391.74	$17 134.54	$19 648.94	$2 298.97	$880.92	$3 717.01
Patient transport	14	$14 902.27	$14 643.84	$15 160.70	$1 064.45	$555.86	$1 573.03
Ultrasound	24	$14 297.57	$14 259.37	$14 335.77	$595.73	$435.60	$755.86
Home care	9	$12 741.23	$10 911.29	$14 571.16	$1 415.69	$208.78	$3 040.16
Emergency consultation	29	$12 208.50	$12 179.54	$12 237.47	$420.98	$281.75	$560.22
Social work	28	$8 536.64	$8 507.17	$8 566.12	$304.88	$171.57	$438.19
Biopsies	6	$7 406.28	$7 329.87	$7 482.68	$1 234.38	$811.25	$1 657.51
Ambulatory oxygen care	4	$6 811.74	$4 487.93	$9 135.55	$1 702.94	$1 388.23	$4 794.10

USD: constant U.S. dollars 2023.

Discussion

Considerable efforts have been made to implement strategies for the prevention, detection, treatment, and rehabilitation of women with breast cancer.[30-32] Therefore, it is necessary to estimate the costs of care for this type of cancer to make decisions related to health interventions and establish health policies aimed at this population.[1,33-37] In Colombia, data on the cost of breast cancer care are scarce or their estimation is highly variable.[4-6]

In the present study, carried out with information from breast cancer patients (all belonging to the contributory regime) treated between 2010 and 2016 at an EPS with a nationwide presence, it was evident that Bogotá D.C. (24.96%), Antioquia (12.76%), and Atlántico (9.96%) were the most frequent places of residence. This is partially in line with what was reported in the *Cuenta de Alto Costo - CAC* (High Cost Account) report on new breast cancer patients registered between January 2, 2022, and January 1, 2023 (8 702 cases), where the central region (Antioquia, Caldas, Risaralda, and Tolima) had the highest number of new cases (n=2 731, 31. 4%), followed by the Caribbean region (Atlántico, Bolívar, Cesar, and Córdoba) (n=2 051, 23.7%), and the Bogotá D.C. region (n=1 354, 15.6%).[38]

In the present study, the median age at diagnosis was 61 years (±11.22), which is slightly higher than the figure provided in 2023 in Colombia in the CAC report[38] for patients with breast cancer affiliated to both the contributory and subsidized regimes (median: 59 years, IQR: 49-68), but similar to that reported by Giaquinto *et al.*,[39] who found that, based on global statistics for 2022, the overall mean age at the time of diagnosis of female breast cancer was 62 years, although it varied between 57 and 64 years depending on the ethnicity of the patients. It should be kept in mind that the diversity of clinical-pathological characteristics in different regions and ethnicities partly explains the global epidemiological pattern of breast cancer.[40]

Furthermore, the present study found that out of the 465 patients for whom cancer staging data were available, the most frequent stage was stage II (41.71%), followed by stage III (28.82%). Even though the information reported in the country on cancer stage at the time of diagnosis is scarce, our findings are similar to those of the CAC report,[38] which described that the most frequent stages of breast cancer patients in 2023 were TNM II and III: 42.49% and 21.52%, respectively, for the 6 255 patients affiliated to the contributory scheme, and 39.75% and 34.16%, respectively, for the 2 652 patients affiliated to the subsidized scheme. Similarly, Omer *et al.*[41] conducted a study of 419 patients diagnosed with breast cancer between September 2019 and December 2020 at a tertiary care center in Saudi Arabia and found that most of them presented with TNM stages II and III (55.2%).

The analysis by phases of care, based on an individual contribution in months for each patient, showed that there was a larger number of patients in the continuing phase (n=585), followed by the initial phase (n=483), and the last year of life phase (n=46). The lower number of patients in the last year of life reflects high survival rates, which are improving as evidenced by Duarte *et al.*[42] in a study analyzing incidence data from breast cancer registries in Colombia, which showed an increase in the 5-year survival rate from 65.70 in the period 1995-1999 to 72.10 in the period 2010-2014.

Changes in breast cancer incidence have coincided with generally decreasing mortality rates related to the combination of progress in treatment and early detection through screening in most developing and historically high-risk countries. As a consequence, the number of women living with a history of breast cancer has also increased markedly, with an estimated 7.8 million in 2020 (5-year prevalence).[43]

In the present study, the average annual net costs of breast cancer care were higher in the continuing phase (27 325 443.08 USD), followed by the initial phase (24 431 719.80 USD), and the last year of life phase (6 786 347.62 USD). In addition, the average annual net cost per patient was 50 583.27 USD, 46 710.16 USD, and 147 529.30 USD in the initial, continuing, and last year of life phases, respectively (Tables 3, 4, and 5). This behavior is partially similar to that reported for this type of cancer in other studies. For example, Yabroff *et al.*[13] calculated the monthly net costs of care for 718 907 elderly cancer patients using Medicare claims in the United States between January 1, 1999, and December 31, 2003, and found that the average monthly costs of care for breast cancer patients (expressed in 2004 USD) were 11 728 USD in the initial phase (n=27 456), 1 201 USD in the continuing phase (n=131 018), and 29 199 USD in the last year of life phase (n= 35 906). In turn, Marrioto *et al.*,[44] based on data for survivors aged ≥65 years diagnosed with cancer between 2000 and 2012 obtained from the Surveillance, Epidemiology and End Results database of the U.S. National Cancer Institute and Medicare claims data from 2007 to 2013, estimated cancer-attributable health care costs in this population and found that annualized average costs of cancer-attributable medical services costs in breast cancer patients (expressed in 2019 USD) were 33 700 USD for the initial stage (n=126 000), 3 500 for the continuing stage (n=250 100), 73 200 for last year of life phase-cancer related death (n=22 500), and 10 100 for last year of life phase-death from any other cause patients (n=35 900).

On the other hand, drugs accounted for 48.90%, 52.08%, and 66.16% of the average annual net costs of breast cancer care in the initial, continuing, and last year of life phases, respectively, this being the cost-generating event with the highest cost. In addition, the average annual net costs of breast cancer care per phase of care incurred spent in drugs increased from 11 946 205.63 USD in the initial phase to 14 230 578.86 USD in the continuing phase, but it decreased dramatically to 4 489 749.91 USD in the last year of life phase, which is to be expected given the number of patients across phases (411, 556, and 46, respectively). This finding partially agrees with what was described in the study by Marrioto *et al.*,[44] in which the average annual costs of breast cancer care per prescription of oral drugs (in thousands of 2019 USD) were lower in the continuing phase (0.8) than in the initial phase (1.1), but they significantly increased in the last year of life phase-cancer-related death (2.7). In any case, it should be noted that, given the source of the data analyzed (Medicare claims), the research by Marriot *et al.*[44] only provides data for prescription costs of oral drugs and not of drugs in general, as in our study.

This increasing trend in costs related to the use of drugs across the phases of care could be explained by a higher demand in the continuing phase (due to the cancer treatment that usually takes place in this phase) and the last year of life (due to the complications of this type of cancer, which tend to be more frequent and severe at this stage). In this regard, Sun *et al.*,[45] in a systematic review that included 20 studies, point out that the costs of treating this type of cancer increase as the disease progresses, since the costs were 32%, 95%, and 109% higher in patients with stage II, III, and IV cancer at the time of diagnosis, respectively, than in those with stage I cancer.

Another finding worth noting in our study is that the average annual net costs per patient for drugs, diagnostic procedures and treatment, medical devices, specialized medical consultation, clinical laboratory, X-rays, ultrasound, MRI, endoscopy, and emergency consultation were higher in the initial and last year of life phases than in the continuing phase, following a nonlinear U-shaped curve pattern similar to that described by other authors.[3,10,13,23,25,35,36] For our study, the average annual net costs per patient grouped by phases of care represent an important finding considering that the aforementioned

resource groups account for 88.29% of these costs in the initial phase, 80.12% in the continuing phase, and 66.16% in the last year of life phase. In addition, it was found that drugs, diagnostic and treatment procedures, and inpatient surgery accounted for more than 75% of the costs in all three phases of care.

With regard to the percentage composition of the average annual net costs per patient per phase of care, drugs not included in the health benefit plan and charged to the *Unidad de Pago por Capitación - UPC* (capitation payment unit) were assessed, finding that they represented 5.23% of the costs in the initial phase, 45.21% in the continuing phase, and 67.06% in the phase of the last year of life. This increase in the proportion of drug costs in the average annual net costs per patient across phases reflects the incremental burden of the disease as it progresses, considering that the more advanced the cancer (either due to the lack of treatment or because the outcome is not as expected), the more complex the treatment and the more frequent and severe the complications. Consequently, the cost of care, which involves a greater demand for drugs, increases. However, it should be noted that when costs for any drug in general were considered, a U-shaped curve pattern was observed across phases, since drugs represented 57.46%, 54.79% and 69.16% of the annual net costs per patient in the initial, continuing, and last year of life phases, respectively.

Finally, the estimates of average annual net costs per breast cancer patient presented in this study can be incorporated into cost-effectiveness models for cancer control strategies, especially those designed to evaluate treatment interventions in which it is necessary to identify, quantify, and appraise the direct costs of care for the resources used for care.

Although the costs of breast cancer care in the present study were estimated using methods validated in the literature, it has several limitations, namely: 1) the data used to estimate the costs come from only one EPS and in Colombia, at the time of the study, there were 13 active EPSs in the contributory health regime, although this EPS provided health care to 11% of the Colombian population affiliated to the contributory regime at that time;[19,46] 2) although the information used comes from patients residing in various regions of Colombia, the geographic variation in cancer incidence may not be fully reflected in the estimates of breast cancer care costs presented here; 3) the population included in the study represents people with the capacity to pay a monthly premium for affiliation to the health system, so these data do not represent the situation of patients without the capacity to pay; 4) due to its size, the sample cannot be considered representative of the total number of breast cancer cases with payment capacity that were treated in Colombia during the study period; and 5) the estimate of the average annual net costs of breast cancer care by phase of care and the average annual net cost per patient in each phase of care did not include indirect costs for lost productivity or out-of-pocket expenses.

Despite the above, the results of this study provide information for the economic evaluation of the costs of breast cancer care and decision making for the allocation of resources for related activities, procedures, and interventions.

Conclusions

The average annual net cost of breast cancer care by phase of care was higher in the continuing phase, followed by the initial and last year of life phases.

Drugs and diagnostic and treatment procedures, surgery, and hospital stay accounted for the resources with the highest average annual net cost of breast cancer care by phase of care for the three phases analyzed.

The average annual net cost per patient in each phase of care for drugs, diagnostic procedures and treatment, medical devices, specialized medical consultation, clinical laboratory, X-rays, ultrasound, magnetic resonance imaging, endoscopy, and emergency consultation was higher in the initial and last year of life phases and lower in the continuing phase, showing a U-shaped curve pattern. Furthermore, the aforementioned resources represent 88.3%, 80.1%, and 89.3% of the average annual net cost of breast cancer care in the initial, continuing, and last year of life phases, respectively.

Finally, our results provide information on additional burden due to breast cancer care that can be very helpful in the economic evaluation of new treatments and strategies, such as the allocation of resources for prevention, screening, and treatment activities for this type of cancer.

Conflicts of interest

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References

1. Ferlay J, Ervik M, Lam F, Laversanne M, Colombet M, Mery L, et al. Global Cancer Observatory: Cancer Today [Internet]. Lyon, France: International Agency for Research on Cancer; 2024 [cited 2024 Mar 10]. Available from: https://bit.ly/40yOv8m.

2. Schneider PP, Ramaekers BL, Pouwels X, Geurts S, Ibragimova K, de Boer M, *et al.* Direct medical costs of advanced breast cancer treatment: A real-world study in the Southeast of The Netherlands. Value Health. 2021;24(5):668-75. https://doi.org/nn4s.

3. Montiel-Jarquín ÁJ, Santiago-Carrillo MA, García-Galicia A, López-Bernal CA, Miranda-Martínez MA, Loria-Castellanos J. Análisis del coste directo de la atención médica y quirúrgica del cáncer de mama. Estudio comparativo entre etapas temprana y tardía en tercer nivel de atención. Cir Cir. 2023;91(1):28-33. https://doi.org/nn4w.

4. Moreno JA, Muñoz-Galindo I, Guarín N, Díaz J, Arevalo H. Direct costs of health care for breast cancer, the case of a health manteinance organization in Colombia. Value in Health. 2015;18(3):A254. https://doi.org/f3g2x5.

5. Gamboa O, Buitrago LA, Lozano T, Dieleman S, Gamboa C, Guzmán EL, *et al.* Costos directos de la atención del cáncer de mama en Colombia. Rev Colomb Cancerol. 2016;20(2):52-60. https://doi.org/nn9t.

6. Torres GF, Alarcón BA, Reyes-Sanchez JM, Castaño-Gamboa N, Buitrago G. Net costs of breast cancer in Colombia: a cost-of-illness study based on administrative claims databases. Cost Eff Resour Alloc. 2024;22(1):54. https://doi.org/nn9w.

7. Gamboa O, Buitrago G, Patiño AF, Agudelo NR, Saldaña-Espinel L, Eslava-Schmalbach J, *et al.* Fragmentation of Care and Its Association With Survival and Costs for Patients With Breast Cancer in Colombiá. JCO Glob Oncol. 2023;9:e2200393. https://doi.org/gr9snj.

8. Lipscomb J, Yabroff KR, Brown ML, Lawrence W, Barnett PG. Health Care Costing: Data, Methods, Current Applications. Med Care. 2009;47(7 Suppl 1):S1-6. https://doi.org/dmhns2.

9. Barlow WE. Overview of Methods to Estimate the Medical Costs of Cancer. Med Care. 2009;47(7 Suppl 1):S33-6. https://doi.org/ccs8cn.

10. Francisci S, Capodaglio G, Gigli A, Mollica C, Guzzinati S. Cancer cost profiles: The Epicost estimation approach. Front Public Heal. 2022;10:974505. https://doi.org/npj4.

11. Blayney DW, Seto T, Hoang N, Lindquist C, Kurian AW. Benchmark Method for Cost Computations Across Health Care Systems: Cost of Care per Patient per Day in Breast Cancer Care. JCO Oncol Pract. 2021;17(10):e1403-12. https://doi.org/npj8.

12. Bugge C, Brustugum OT, Seether EM, Kristiansen IS. Phase-and gender-specific, lifetime, and future costs of cancer: A retrospective population-based registry study. Medicine (Baltimore). 2021;100(26):e26523. https://doi.org/ntc2.

13. Yabroff KR, Lamont EB, Mariotto A, Warren JL, Topor M, Meekins A, *et al.* Cost of care for elderly cancer patients in the United States. J Natl Cancer Inst. 2008;100(9):630-41. https://doi.org/dkmdx2.

14. Urrego-Novoa JR. Estimación de los costos directos médicos netos de la atención de cáncer de mama en el Sistema General de Seguridad Social de Colombia [thesis on the Internet]. Bogotá D.C.: Universidad Nacional de Colombia; 2024 [cited 2024 Dec24]. Available from: https://repositorio.unal.edu.co/handle/unal/87242.

15. de Oliveira C, Pataky R, Bremner KE, Rangrej J, Chan KK, Cheung WY, *et al.* Phase-specific and lifetime costs of cancer care in Ontario, Canada. BMC Cancer. 2016;16(1):809. https://doi.org/f87vmm.

16. Banegas MP, Yabroff KR, O'Keeffe-Rosetti MC, Ritzwoller DP, Fishman PA, Salloum RG, *et al.* Medical care costs associated with cancer in integrated delivery systems. J Natl Compr Cancer Netw. 2018;16(4):402-10. https://doi.org/gdd2sk.

17. Iacus SM, King G, Porro G. cem : Software for Coarsened Exact Matching. J Stat Softw. 2009;30(9):1-27. https://doi.org/gjjx3g.

18. Iacus SM, King G, Porro G. Causal inference without balance checking: Coarsened exact matching. Political Analysis. 2012;20(1):1-24. https://doi.org/dppdx5.

19. Salud Total EPS-S. Informe de Gestión 2016 [Internet]. Bogotá D.C.: Salud Total EPS-S; 2017 [cited 2024 Nov 16]. Available from: https://bit.ly/4g0LvG7.

20. Organización Panamericana de la Salud (OPS). CIE-10. Clasificación Estadística Internacional de Enfermedades y Problemas Relacionados con la Salud. Volumen 1. Décima Revisión [Internet]. Ginebra: OPS; 2003 [cited 2024 Nov 6]. Available from: https://bit.ly/4asLidJ.

21. Yabroff KR, Warren JL, Schrag D, Mariotto A, Meekins A, Topor M, *et al.* Comparison of Approaches for Estimating Incidence Costs of Care for Colorectal Cancer Patients. Med Care. 2009;47(7 Supplement 1):S56-63. https://doi.org/cndjph.

22. Yabroff KR, Mariotto A, Tangka F, Zhao J, Islami F, Sung H, *et al.* Annual Report to the Nation on the Status of Cancer, Part 2: Patient Economic Burden Associated With Cancer Care. JNCI J Natl Cancer Inst. 2021;113(12):1670-82. https://doi.org/nq5n.

23. Yabroff KR, Mariotto A, Tangka F, Zhao J, Islami F, Sung H, *et al.* Annual Report to the Nation on the Status of Cancer, Part 2: Patient Economic Burden Associated With Cancer Care. J Natl Cancer Inst. 2021;113(12):1670-82. https://doi.org/nq5n.

24. R. Core Team. R: The R Project for Statistical Computing [Software]. 2016 [cited 2024 Sep 21]. Available from: https://www.r-project.org/.

25. Yabroff KR, Warren JL, Brown ML. Costs of cancer care in the USA: a descriptive review. Nat Clin Pract Oncol. 2007;4(11):643-56. https://doi.org/bvz8nf.

26. Park J, Look KA. Health care expenditure burden of cancer care in the United States. Inqiry. 2019;56:46958019880696. https://doi.org/gncgwg.

27. Lao C, Mondal M, Kuper-Hommel M, Campbell I, Lawrenson R. Differences in breast cancer costs by cancer stage and biomarker subtype in New Zealand. Pharmacoecono Open. 2022;6(4):539-48. https://doi.org/nq5p.

28. Colombia. Departamento Administrativo Nacional de Estadística (DANE). Índice de Precios al Consumidor [Internet]. Bogotá D.C.: DANE; 2024 [cited 2024 Sep 21]. Available from: https://bit.ly/3PH3xmd.

29. Sabermahani A, Sirizi MJ, Zolala F, Nazari S. Out-of-Pocket Costs and Importance of Nonmedical and Indirect Costs of Inpatients. Value Health Reg Issues. 2021;24:141-7. https://doi.org/nq5q.

30. Smolarz B, Nowak AZ, Romanowicz H. Breast Cancer-Epidemiology, Classification, Pathogenesis and Treatment (Review of Literature). Cancers (Basel). 2022;14(10): 2569. https://doi.org/gsdqkk.

31. Luo C, Wang L, Zhang Y, Lu M, Lu B, Cai J, *et al.* Advances in breast cancer screening modalities and status of global screening programs. Chronic Dis Transl Med. 2022;8(2):112-23. https://doi.org/nqbk.

32. Hall LH, King NV, Graham CD, Green SMC, Barber A, Neal RD, *et al.* Strategies to self-manage side-effects of adjuvant endocrine therapy among breast cancer survivors: an umbrella review of empirical evidence and clinical guidelines. J Cancer Surviv. 2022;16(6):1296-338. https://doi.org/gqhqfz

33. Figueiredo FWDS, Almeida TCDC, Cardial DT, Maciel EDS, Fonseca FLA, Adami F. The role of health policy in the burden of breast cancer in Brazil. BMC Womens Health. 2017;17(1):121. https://doi.org/ghd86h.

34. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, *et al.* Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229-63. https://doi.org/gtp98r.

35. Trogdon JG, Ekwueme DU, Poehler D, Thomas CC, Reeder-Hayes K, Allaire BT. Medical costs of treating breast cancer among younger Medicaid beneficiaries by stage at diagnosis. Breast Cancer Res Treat. 2017;166(1):207-15. https://doi.org/gcgn7c.

36. Trogdon JG, Baggett CD, Gogate A, Reeder-Hayes KE, Rotter J, Zhou XI, *et al.* Medical costs associated with metastatic breast cancer in younger, midlife, and older women. Breast Cancer Res Treat. 2020;181(3):653-65. https://doi.org/nq5r.

37. Hu L, Li L, Ji J, Sanderson M. Identifying and understanding determinants of high healthcare costs for breast cancer: a quantile regression machine learning approach. BMC Health Serv Res. 2020;20(1):1066. https://doi.org/gnwmvg.

38. Fondo Colombiano de Enfermedades de Alto Costo C de AC (CAC). Situación del cáncer en la población adulta atendida en el SGSSS de Colombia 2023. Bogotá D.C.: CAC; 2024.

39. Giaquinto AN, Sung H, Miller KD, Kramer JL, Newman LA, Minihan A, *et al.* Breast Cancer Statistics, 2022. CA Cancer J Clin. 2022;72(6):524-41. https://doi.org/gqxgp5.

40. Xu H, Xu B. Breast cancer: Epidemiology, risk factors and screening. Chinese J Cancer Res. 2023;35(6):565-83. https://doi.org/nqw3.

41. Omer AAA, Bin Dayel SA, Hummedi ASA, Almuhaimed NIA. The epidemiological and clinicopathological features of breast cancer in Riyadh, Saudi Arabia. Saudi Med J. 2024;45(3):288-94. https://doi.org/nq3g.

42. Duarte C, Salazar A, Strasser-Weippl K, de Vries E, Wiesner C, Arango-Gutiérrez A, *et al.* Breast cancer in Colombia: a growing challenge for the healthcare system. Breast Cancer Res Treat. 2021;186(1):15-24. https://doi.org/gh4mbx.

43. Arnold M, Morgan E, Rumgay H, Mafra A, Singh D, Laversanne M, *et al.* Current and future burden of breast cancer: Global statistics for 2020 and 2040. Breast. 2022;66:15-23. https://doi.org/gsb5hn.

44. Mariotto AB, Enewold L, Zhao J, Zeruto CA, Robin Yabroff K. Medical care costs associated with cancer survivorship in the United States. Cancer Epidemiol Biomarkers Prev. 2020;29(7):1304-12. https://doi.org/gnwmss.

45. Sun L, Legood R, Dos-Santos-Silva I, Gaiha SM, Sadique Z. Global treatment costs of breast cancer by stage: A systematic review. PLoS One. 2018;13(11):e0207993. https://doi.org/gfpr8t.

46. Colombia. Dirección de Regulación de la Operación del Aseguramiento en Salud, Riesgos Laborales y Pensiones. Boletín del aseguramiento en salud. Boletín No. 01 - Primer trimestre 2017. Bogotá D.C.: Ministerio de Salud y protección social; 2017.