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RESEARCH

The emperor has no clothes—the need for standardized anatomical segment definitions in the management of colon cancer

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Abstract

Purpose There is no standardized classification system for defining segments of colon carcinoma within cancer registries. We aimed to conduct a systematic literature review on studies that specifically address colon cancer and provide definitions for each segment.

Methods Five authors conducted an independent systematic literature search of studies on colon cancer between 01/1992 and 11/2023. Only English-language original articles including cohort studies, case series, previous reviews, meta-analyses, and randomized clinical trials were considered for inclusion. Exclusion criteria were case reports, editorials, and letters. After identifying the relevant studies, those describing particular colon cancer segments were assessed. Whether or not oncologic outcomes were assessed, whether any definitions for particular colon cancer segments were used, were reviewed and extracted.

Results A total of 9059 articles were screened, and 1143 of them were identified and included in the current study. Out of 1143 included articles, 130 defined the specific colon cancer segment. Distribution of included articles with definition ratios for each segment was as follows: Cecum ($n=2$; 2.35%), ascending colon ($n=2$; 1.94%), hepatic flexure ($n=2$; 33.3%), transverse colon ($n=33$; 42.85%), splenic flexure ($n=38$; 58.46%), descending colon ($n=16$; 8.04%), sigmoid colon ($n=34$; 4.99%), and rectosigmoid colon ($n=16$; 15.23%). A total of 397 articles reported long-term oncologic outcomes.

Conclusion Our study unveils discrepancies in the published literature, revealing that nearly 10% of the studies focusing on colon cancer provide various definitions for each colonic segment. Standardizing the definitions of colon cancer segments is essential to prevent the use of arbitrary definitions, which can result in inconsistency and hinder accurate outcome assessments.

Keywords Colon cancer · Definition · Standardization

Introduction

An absence of uniform definitions of colorectal segments impedes efforts to accurately compare outcomes within specific colon segments and to establish standardized cancer treatment approaches. While the rectum has clearly defined boundaries, there is no consensus on the precise characteristics of certain regions of the colon, where almost 70% of malignancies develop [1]. In the last two decades, numerous reports have explored how the exact location of the initial tumor is related to the prognosis of colorectal cancer [2, 3]. Several studies indicate a distinction between proximal and distal colon cancer regarding clinicopathological features, tumor behavior, genetic profiles, and patient survival [4–6].

Oncologic outcomes of colorectal cancer vary not only from center to center but also from surgeon to surgeon due to numerous factors. One primary reason may be the unclear definitions of the boundaries of each segment. Anatomically, the colon is classified into eight distinct parts: the cecum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid colon, and rectosigmoid [7]. This classification is acknowledged by well-established

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societies and organizations that provide a common language for recording, reporting, and monitoring oncologic outcomes, such as the International Classification of Diseases (ICD), American Joint Committee on Cancer (AJCC), and European Society for Medical Oncology (ESMO). However, the precise margins demarcating each segment may differ across these organizations and among surgeons. For example, one surgeon may register the splenic flexure as descending, another as transverse, and yet another as the splenic flexure in their cancer database. A thorough examination of the literature highlights the necessity of addressing discrepancies in identifying specific parts of the colon and establishing a consensus on these definitions.

Vague definitions within the scientific literature prevent us from making accurate comparisons, which then hinders appropriate patient monitoring. Precise and uniform definitions of each colon segment are, therefore, essential for the correct documentation and evaluation of cancer therapy, as well as for prognosis. The aim of this study is to conduct a comprehensive assessment and analysis of the presence and variability of definitions for each segment of the colon as published in the colorectal cancer literature.

Materials and methods

The authors of this study meticulously reviewed the literature on colon segments from January 1992 to November 2023, and "Terminologia Anatomica" was also reviewed [8]. A comprehensive search was conducted throughout Cochrane, Embase, PubMed, and Scopus, all of which are well-known scholarly archives. The decision to begin in January 1992 was made to coincide with the start of the ICD-10 coding system to maintain relevance and uniformity in the literature chosen. The research language included specific terms like "colon cancer," "colonic neoplasm," and "colonic carcinoma," as well as location markers such as "cecum," "ascending," "hepatic flexure," "transverse colon," "splenic flexure," "descending," "sigmoid," and "rectosigmoid." The search criteria were narrowed down by restricting the study scope to English language articles, as well as by removing case reviews, case series with populations of 20 or fewer patients, and articles published before 1992.

The search process followed PRISMA guidelines, as demonstrated by the inclusion of a flow chart (Fig. 1). Abstracts were reviewed first, and relevant articles were then downloaded for further research. After acquiring the chosen publications, a detailed examination was conducted that went beyond just the abstracts to include the Introduction, Material, and Method sections. This comprehensive analysis focused on identifying segment definitions pertaining to colon anatomy. Examining these parts was crucial to fully comprehending the methods used to define colon segments in the chosen research. Five separate researchers rigorously conducted the search and data extraction to ensure the review process' robustness. The gathered data, such as population demographics, long-term survival results in oncology research, anatomical location descriptions, publication year and nation, study design, and subject traits, were recorded in an Excel spreadsheet.

To improve the research's dependability and consistency, the next stage was to match all papers based on their DOI to avoid duplication. The five independent researchers worked together to locate and extract data.

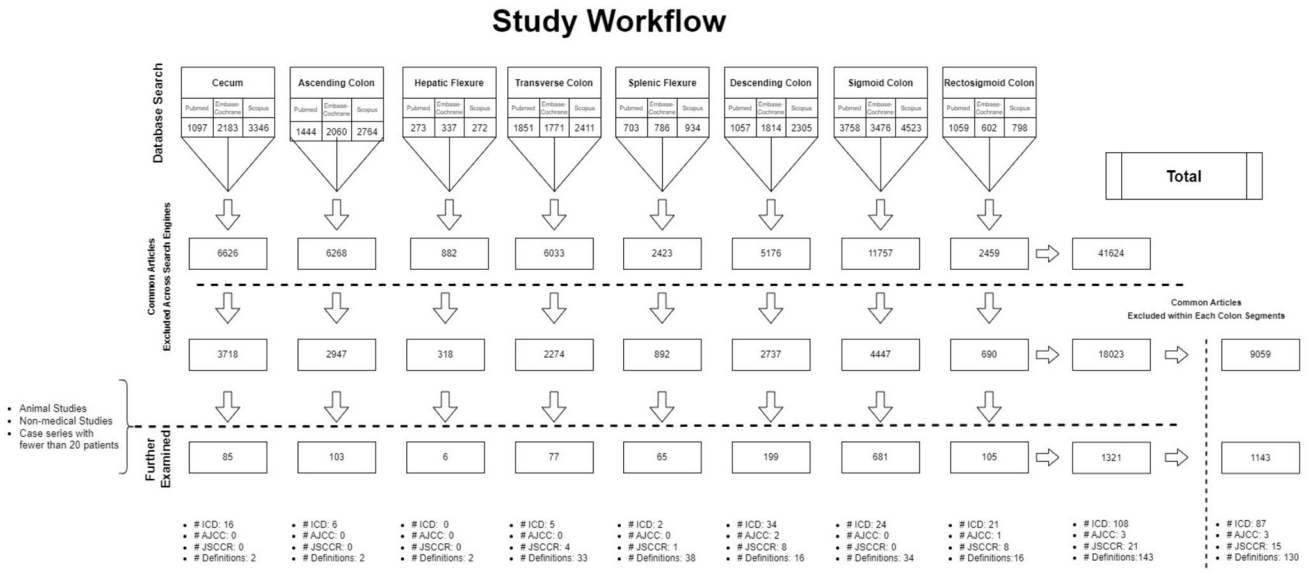


Fig. 1 Flowchart detailing the literature search

Descriptive statistics, such as the patient count per trial, duration of follow-up, and year of publication, were also included.

Results

The initial examination of the literature revealed a total of 41,624 publications. After excluding duplicate articles across the search engines, 18,023 papers were identified for further analysis. Following a first assessment of titles and abstracts, 16,702 studies were deemed ineligible for inclusion based on predefined criteria. The flowchart (Fig. 1) illustrates the comprehensive rationales for the inclusion and exclusion of publications. After following the specified criteria for inclusion and eliminating any duplicate articles within each segment of the colon and across all parts of the colon (some articles were included in the results for multiple colon segments), a total of 1143 publications remained. The remaining articles underwent a comprehensive evaluation by five researchers who operated independently.

Out of 1143 included articles, 130 (11%) defined the specific colon cancer segment in the manuscript. The distribution of included articles with definitions for each segment was as follows: cecum ($n=2$; 2.35%), ascending colon ($n=2$; 1.94%), hepatic flexure ($n=2$; 33.3%), transverse colon ($n=33$; 42.85%), splenic flexure ($n=38$; 58.46%), descending colon ($n=16$; 8.04%), sigmoid colon ($n=34$; 4.99%), and rectosigmoid colon ($n=16$; 15.23%). Among these studies, 50 offered distinct definitions, as indicated in Table 1. Figure 1 displays the quantity of studies that define each segment of the colon and the distribution based on several classification systems, namely ICD, AJCC, and Japanese Society for Cancer of the Colon and Rectum (JSCCR). There was a total of 87 papers that classified colon segments according to the ICD system, three articles that adhered to the AJCC recommendations, and 15 studies that utilized the JSCCR criteria.

Among the colon segments, the splenic flexure is a particularly prominent topic, with a total of 58.46%, followed by the transverse colon at 42.85%. The hepatic flexure, although not comprehensive in terms of article count, has a high definition rate of 33.3%. The cecum and ascending colon exhibit definition rates of 2.35% and 1.94%, respectively (Table 2).

Descriptive characteristics appear in Figs. 2 and 3. Our study included an analysis of 12 distinct types of studies spanning all segments, with retrospective cohorts emerging as the predominant type at 19.5% ($n=67$, Fig. 2). From a geographical perspective, it is evident from Fig. 3 that the bulk of studies were carried out in Asia.

The study encompassed a comprehensive dataset including 15,052,012 patients, with an average of 18,844 patients featured in each study. The highest concentration of patients had cancers of the descending colon, encompassing a total of 5,184,163 individuals. Within the examined research, a total of 397 studies provided information on oncologic outcomes. The total number of studies providing oncological outcomes for each colon segment and the number of studies with defined segments are given in Fig. 4.

Discussion

Auditing is of paramount importance in achieving accuracy in surgical outcomes. To monitor the treatment results of colorectal diseases, considerable efforts are made to record and report surgical and oncologic outcomes at each center. However, our study revealed a critical oversight: "The Emperor Has No Clothes." We found that most published colorectal literature lacks relevant definitions for each colon segment. Only 11% of the articles included definitions with specific boundaries. Moreover, we identified multiple unique definitions for each colon segment, with up to ten variations for the transverse, sigmoid, and rectosigmoid colon segments. Furthermore, according to our research, out of a total of 397 studies that reported oncological findings, only 79 studies provided definitions for colon segments. Alarmingly, almost 35% of the articles reporting oncologic outcomes and only 4.6% of randomized trials included any segmental definitions.

Upon reviewing studies that report oncologic outcomes for transverse and splenic flexure carcinomas, we observed that many of them often include the distal one-third of the transverse colon in the definitions of both segments [2, 3 and 5–73 references in appendix]. This overlap creates confusion, as the same segment is reported as part of both transverse colon and splenic flexure cancer, precluding a precise understanding of oncologic outcomes. This observation underscores the lack of a standardized system in current cancer registries for delineating individual segments of colon carcinoma, a stark contrast to the well-defined classifications observed for rectal cancer [9]. This lack of standardization may stem from surgeons' focus on surgical resection options and margins, leading many to believe that the type of resection is more crucial than the precise delineation of colonic segments. Furthermore, some may assume that a few centimeters of difference do not significantly impact overall oncologic outcomes. However, classifying colorectal cancer simply as right, left, or rectal is inadequate for assessing the oncological and surgical results associated with each location. Recent studies have documented substantial differences in the molecular characteristics of colorectal carcinoma tumors depending on their sub-site. Additionally, there are distinct differences in vascular anatomy and lymphatic dissemination among different regions of the colon, especially for tumors

Table 1 Unique definitions of colon segments

Cecal carcinoma	Segments colon by diameter, the ileocecal valve was selected as a boundary between the ascending colon and the cecum, where the valve was included in the proximal segment [21]
	the anatomic site was ''translated'' into a specific site based on the distance from anal canal: 150 cm (cecum) [22]
Ascending colon carcinoma	The anatomic site was ''translated'' into a specific site based on the distance from anal canal: 132 to 147 cm (ascending) [22]
	Tract between 10 cm proximal from the curve and ileocecal valve [23]
Hepatic flexure carcinoma	Colon cancers located in the hepatic flexure were defined as those occurring within 10 cm of the hepatic flexure [24]
Transverse colon carcinoma	Located between the hepatic and splenic flexures, including the flexures [25–29]
	Involves the transverse colon excluding the hepatic and the splenic flexure [13, 30–45]
	Any colonic segment located in the hepatic flexure, mid-transverse colon, or splenic flexure [46, 47]
	Mid-transverse colon is located in the mid part of the transverse colon, excluding the 10-cm distal third in the left colonic angle (splenic flexure) and the 10-cm proximal part in the right colonic angle (hepatic flexure) of the transverse colon. The mid-transverse location was determined by surgical exploration [48, 49]
	Mid-transverse colon is located in the middle part of the transverse colon, excluding the 5-cm distal segment from the hepatic flexure and the 5-cm proximal segment from the splenic flexure, according to both preoperative (colonoscopic and radiologic) and intraoperative findings [50]
	Mid-transverse colon cancer is defined as a tumor located in the middle one-third of the transverse colon. Tumors located at either flexure were excluded. The mid-transverse location was determined by both preoperative imaging and surgical exploration [51–53]
	Transverse colon cancer is defined as a tumor located between the hepatic and splenic flexures. The transverse colon was divided into thirds according to preoperative CT images and intraoperative findings. The right-sided transverse colon is located between the hepatic flexure and the right branch of the middle colic artery (MCA); the left-sided transverse colon is located between the left branch of the MCA and the splenic flexure; and the middle segment is located between the right and left branches of the MCA [54, 55]
	Tract between 10 cm after the splenic flexure and 10 cm before the hepatic flexure [23]
	A tumor that was located on the transverse colon and fed by the MCA was defined as transverse colon cancer [29]
	The anatomic site was ''translated'' into a specific site based on the distance from anal canal: 82 to 132 cm (transverse) [22]
Splenic flexure carcinoma	The angle between the transverse and descending colon [56, 57]
	10 cm from either side where the distal transverse colon turns running towards to the proximal descending colon [58–62]
	From the distal third transverse colon to the upper third descending colon [58, 63–71]
	Location at the left third of the transverse colon, the angle, and the first part of the descending colon [67, 72, 73]
	Location in the distal third of the transverse colon, or in the left colonic corner, or in the proximal descending colon within 10 cm from the flexure [15, 74–84]
	A splenic flexure cancer (colonic segment between the mid transverse colon and first part of the ascending colon) [85]
	A tumor that was located on the transverse colon near the splenic flexure or descending colon near the splenic flexure and fed by both the MCA and LCA was defined as splenic flexure cancer [29]

Table 1 (continued)

Descending colon carcinoma (DCC)	DCC was defined as carcinoma that developed from the distal site of the splenic flexure to the sigmoid colon-descending colon junction (SDJ) [86]
	The location of the tumor was categorized according to the location of the distal border of tumor as descending colon (between brim of the pelvis and splenic flexure) [87]
	Cancer located from the left flexure to the sigmoid colon was defined as left-sided colon cancer [88]
	Descending colon was defined as the segment fixed to the retroperitoneum extending from the left colic flexure to the height of the iliac crest, and the SD (sigmoid descending) junction was defined as the segment fixed to the retroperitoneum below the iliac crest based on barium enema examination and CT[89]
	Descending colon: straight segment between 10 cm from the splenic flexure and 40 cm from the anus [23]
	Descending colon cancer was defined as tumors located in the area between the proximal splenic flexure and the sigmoid colon descending colon junction detected by presurgical tests such as computed tomography, colonoscopy, or PET0CT [90]
	A tumor that was located on the descending colon and fed by the LCA was defined as descending colon cancer [29]
	The anatomic site was ‘‘translated’’ into a specific site based on the distance from anal canal: 57 to 82 cm (descending) [22]
Sigmoid colon carcinoma	Tumors located 15.1 to 30 cm from the anal verge were classified as sigmoid cancer
	Sigmoid colon defined as 10 to 60 cm from the anus [87, 91, 92]
	The sigmoid colon (10–25 cm from the level of the external anal aperture) [93, 94]
	The transition between the rectum and the sigmoid is anatomically defined (at the level of the third sacral vertebra [95, 96]
	Tumor was located ahead of the rectum, within the first 60 cm of the distal colon, it was defined as a tumor of the sigmoid colon [97–99]
	The proximal sigmoid border was considered to start at the first curve after the descending colon [100]
	The mesorectal-mesocolic junction as recognized by the sigmoid take-off28 was used as the distal landmark to define sigmoid tumors [101, 102]
	Tortuous segment between 40 and 15 cm from the anus (last Houston valve) [23]
	the anatomic site was ‘‘translated’’ into a specific site based on the distance from anal canal: 17 to 57 cm (sigmoid) [22]
	The location of the tumor was categorized according to the location of the distal border of tumor as sigmoid (between rectosigmoid junction and brim of the pelvis) [87]
Rectosigmoid colon carcinoma	Rectosigmoid junction is considered to be at the level of third sacral vertebra [103]
	Rectosigmoid junction, or distal sigmoid colon (generally 10 to 25 cm above anal verge) [104–106]
	Rectosigmoid (12.1–17 cm) [107–109]
	Sigmoid take-off is a newly emerging landmark that defines the rectosigmoid junction [95, 101, 110, 111]
	Rectosigmoid (defined as 10–30 cm from the anal verge) [112]
	Bowel segment proximal to the rectum between 16.1 cm and 20 cm was defined as the rectosigmoid junction [113, 114]
	Between the last Houston valve and the first tract of the sigmoid segment [23]
	The anatomic site was ‘‘translated’’ into a specific site based on the distance from anal canal: 15 to 17 cm (recto-sigmoid) [22]
	We defined rectosigmoid cancer when the tumor was located in the transitional area where the tenia coli begin to merge [115]
	The location of the tumor was categorized according to the location of the distal border of tumor as rectosigmoid colon (between 15 cm from the anal verge and rectosigmoid junction) [87]

located in the flexures and transverse colon, where surgical interventions also vary significantly. Consistent with this, statistically significant differences in colon cancer-specific survival have been recently reported in relation to tumor location from the cecum to the sigmoid colon, excluding the rectum.

Efetov et al. have demonstrated sigmoid colon vascular variability and benefits of selective arterial ligation. The

Table 2 Number of definitions for each colon segment

	Cecal carcinoma	Ascending colon carcinoma	Hepatic flexure carcinoma	Transverse colon carcinoma	Splenic flexura carcinoma	Descending colon carcinoma	Sigmoid colon carcinoma	Rectosigmoid colon carcinoma	All segments
Number of total papers	85	103	6	77	65	199	681	105	1143
Number of papers with definition	2	2	2	33	38	16	34	16	130
Unique definitions	2	2	1	10	7	8	10	10	50

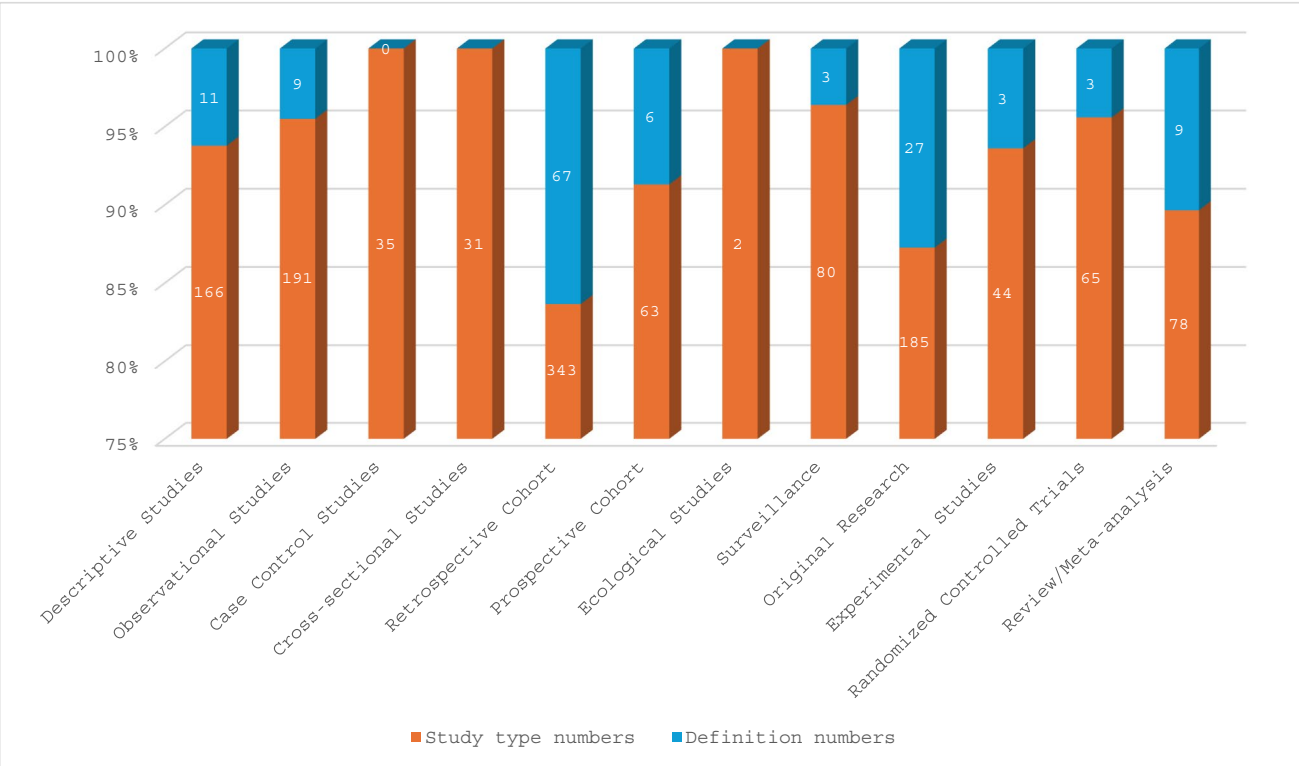


Fig. 2 Study types/definitions

study shows that the sigmoid colon also has rich vascular anatomy as the transverse colon and flexures, and the study emphasizes that, just as middle-colic/left colic variability shapes operative strategy for flexural tumors, inferior-mesenteric branching patterns justify a tailored, vessel-guided approach in distal left-sided resections [10]. Kuzu et al. also showed both the vascular variations of the right colon and the collateral system of intermesenteric anastomosis in fresh cadavers [11, 12]. Because two patients do not share an identical mesenteric layout, reliance on arterial landmarks alone is of limited practical value. Routine preoperative CT angiography is not universally performed, and D3 lymphadenectomy, particularly for right-sided tumors, is far from standard practice. Consequently, surgeons cannot consistently visualize these vascular variants intraoperatively.

Our study revealed that ten definitions were used for the transverse and sigmoid colon alone and seven for the splenic flexure. In addition to that, we found that the splenic flexure is particularly prominent with a definition ratio of 58.46%, followed by the transverse colon with a ratio of 42.85%, both suggesting a significant focus on comprehensive studies pertaining to these specific areas. However, these fluctuating definitions in study designs might considerably limit the comparison of results. The presence of heterogeneity among studies is a prevalent issue in systematic reviews and meta-analyses, which might impede the generalization

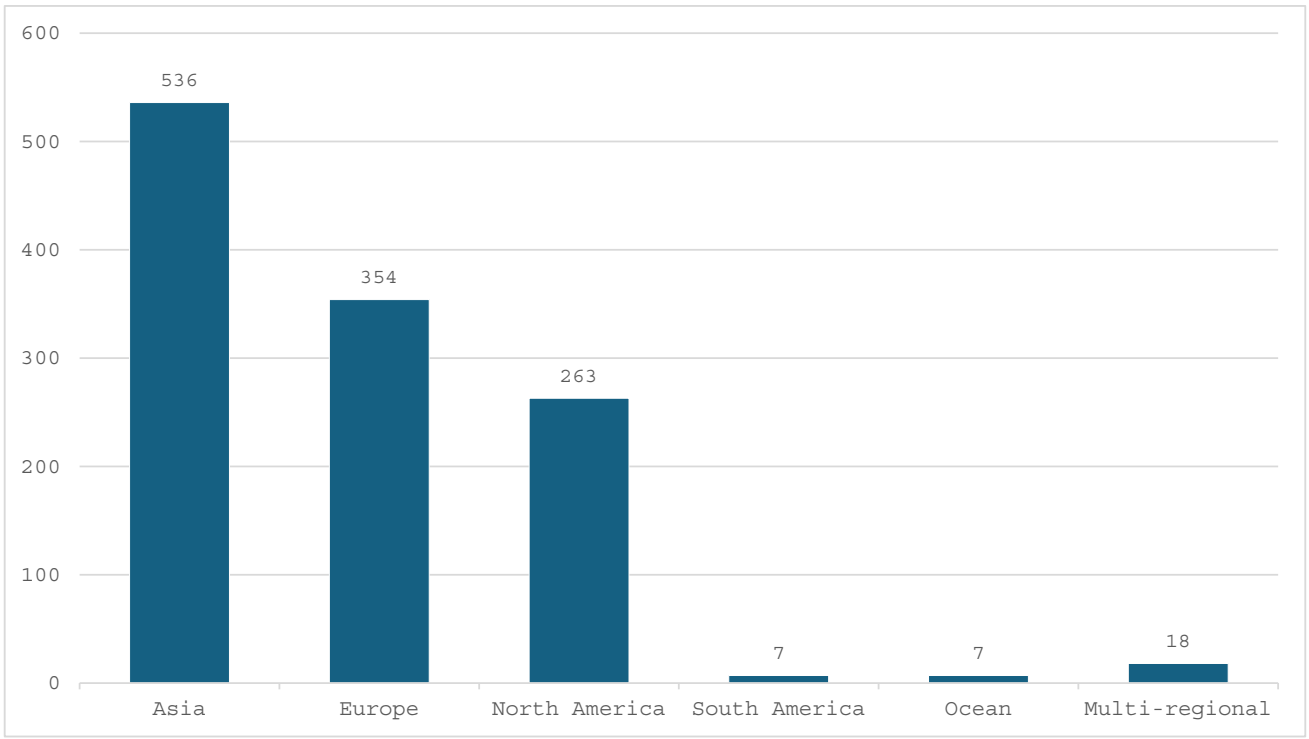


Fig. 3 Study regions

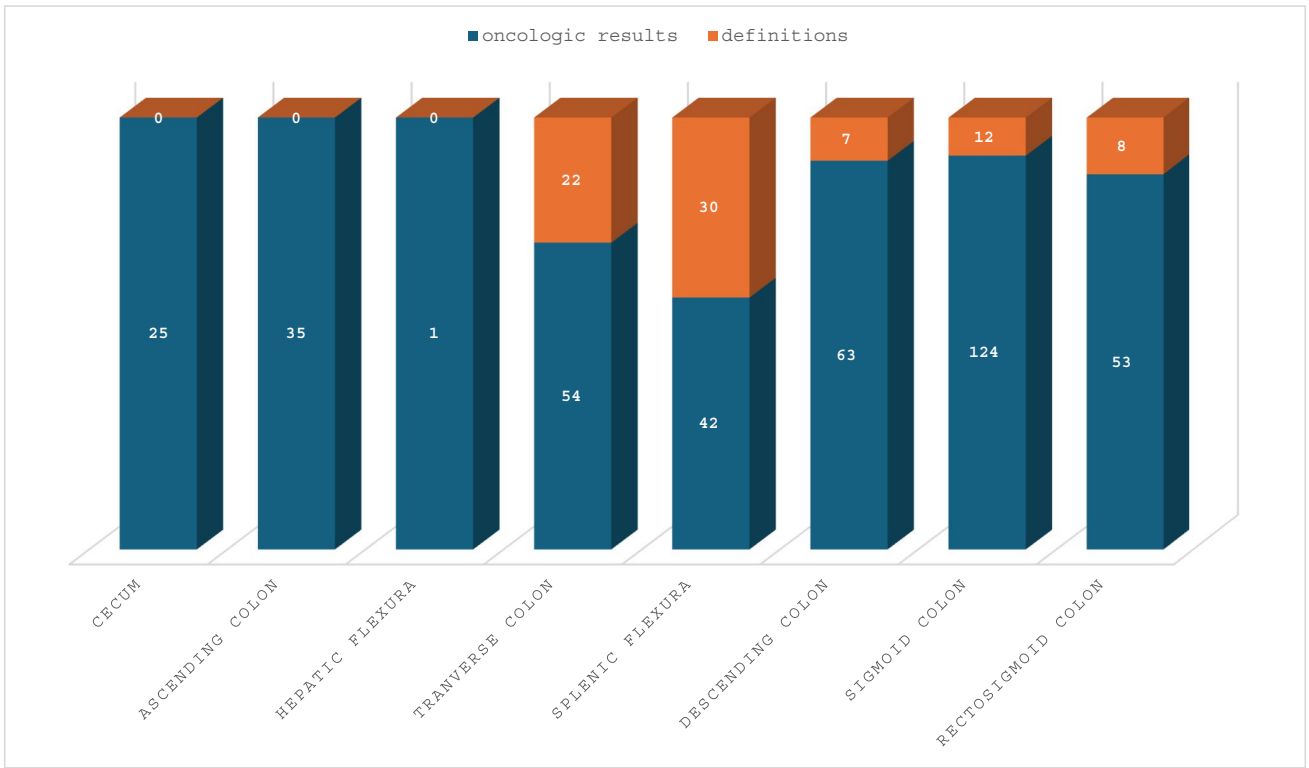


Fig. 4 Oncologic results/definition (*n*)

of conclusions. For example, in a meta-analysis reviewing oncological outcomes of transverse colon cancer, the definition of the transverse colon was missing in four studies, and two different definitions were used in the remaining seven studies [13]. In another meta-analysis, the outcomes of extended right hemicolectomy, left hemicolectomy, and segmental resection for splenic flexure cancer were reported to be similar. However, the definition of the splenic flexure was missing in four out of seven studies, and the rest had two different definitions [14]. The same issue was noted in a meta-analysis of seven studies involving 2397 patients, comparing the outcomes of laparoscopic and open operations for splenic flexure tumors [15]. Another example is a review by Morarasu et al. of 4355 participants from seven studies on the oncologic outcomes of sigmoid cancer. Only two studies provided adequate definitions differentiating the upper and lower boundaries of the colon segment, while the rest either lacked this information or did not state the upper limits of the sigmoid colon [16]. These instances raise doubts regarding the dependability of the findings. The accuracy of these cancer-related results is questionable due to the lack of standardized definitions regarding the precise segmental location of the tumors.

Since the invention of dossier-style medical records in 1907, electronic health records (EHRs) or electronic medical records (EMRs) have become widespread throughout healthcare facilities worldwide [17]. These records contain a vast amount of clinical data that can be useful for multiple purposes, including cancer research. Accurate identification of cancer cases and the essential characteristics needed to describe a cancer population are of paramount importance for auditing and research. However, these records are often hindered by the lack of definitive cancer details in coded fields [18]. Notably, less than 10% of published articles use definitions according to well-known organizations, with the most used being the ICD. However, ICD classification systems provide subjective or arbitrary definitions for each colon segment that lack standardized boundaries. Luhn et al. assessed the accuracy of ICD codes for left, right, and transverse colon tumor sites by calculating sensitivity, specificity, positive predictive value, and negative predictive value [19]. Although they did not individually assess each location within the right and left colon, the sensitivity, negative predictive value, and positive predictive value showed lower performance, ranging from 49–63%, 72–97%, to 64–92%, respectively. Nevertheless, the specificity of structured data for tumor location (left, right, and transverse colon) was high, ranging from 92 to 98%. It is evident that the arbitrary definitions of each colonic segment may preclude outcome comparisons among different centers. In contrast to Western classifications, the Japanese Society for Cancer of the Colon and Rectum sought to establish a uniform approach to the treatment of colorectal cancer, mitigate discrepancies, and promote communication and comprehension between medical practitioners and patients [20]. As a result, the JSCCR classification includes upper and lower borders for each colonic segment, allowing for better comparisons.

Scientific writing must provide accurate descriptions of methods and results in order to ensure consistency and clarity. Standardized terminology is essential to facilitate meaningful comparisons. To the best of our knowledge, this is the first study in the literature focusing on the exact definitions of each colon segment, but the retrospective nature of the study has its own limitations. Additionally, we only searched English language literature in three academic research search engines.

Here, we demonstrated that there is a significant lack of a universally recognized categorization method that can effectively differentiate and accurately identify the various segments of the colon. This gap is observed both within cancer registries and when enrolling patients in clinical research. To enable a meaningful and comprehensive comparison of oncologic outcomes among different cancer registries, it is crucial to implement precise guidelines for standardizing data collection and analysis in each domain. To achieve this, we need anatomically defined landmarks and boundaries for each specific colon segment to prevent arbitrary speculation. The absence of such standardization impedes the ability to conduct comparative analyses of outcomes, thereby hindering potential advancements in treatment options. Therefore, further methodical research is crucial for improving the quality of scientific papers.

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Data availability The anonymized dataset supporting this study is available from the corresponding author upon reasonable request.

Declarations

Competing interests The authors declare no competing interests.

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