Received:
19 September 2016

Revised:
15 September 2017

Accepted:
20 September 2017

<https://doi.org/10.1259/bjr.20160755>

Cite this article as:

Mohammed MF, Chahal T, Gong B, Bhulani N, O'Keefe M, O'Connell T, et al. Trends in CT colonography: bibliometric analysis of the 100 most-cited articles. *Br J Radiol* 2017; **90**: 20160755.

REVIEW ARTICLE

Trends in CT colonography: bibliometric analysis of the 100 most-cited articles

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ABSTRACT

Our purpose was to identify the top 100 cited articles, which focused on CT colonography (CTC). This list could then be analysed to establish trends in CTC research while also identifying common characteristics of highly cited works. Web of Science search was used to create a database of scientific journals using our search terms. A total of 10,597 articles were returned from this search. Articles were included if they focused on diagnostic imaging, imaging technique, cost-effectiveness analysis, clinical use, patient preference or trends in CTC. Articles were ranked by citation count and screened by two attending radiologists. The following information was collected from each article: database citations, citations per year, year published, journal, authors, department affiliation, study type and design, statistical analysis, sample size, modality and topic. Citations for the top 100 articles ranged from 73 to 1179, and citations per year ranged from 4.5 to 84.21. Articles were published across 22 journals, most commonly *Radiology* ($n = 37$) and *American Journal of Roentgenology* ($n = 19$). Authors contributed from 1 to 20 articles. 19% of first authors were affiliated with a department other than radiology. Of the 100 articles, the most common topics were imaging technique ($n = 40$), diagnostic utility of imaging ($n = 28$) and clinical uses ($n = 18$). Our study provides intellectual milestones in CTC research, reflecting on the characteristics and quality of published literature. This work also provides the most influential references related to CTC and serves as a guide to the features of a citable paper in this field.

INTRODUCTION

Bibliometric is the statistical analysis of publications and medical literature. Methods of bibliometrics are used in academic fields to provide analysis of scientific literature. It is used by researchers to explore the impact of their field, of a set of researchers or of a certain publication.^{1,2} Bibliometrics has a range of applications and its impact continues to soar within the scientific community.

Bibliometrics analyses both qualitative and quantitative data within publications and a major strength is its ability to scrutinize citation analysis. Citation analysis examines publications to identify the amount of impact they have on their respective fields.¹⁻⁴ Bibliometric analyses are very useful for identifying trends in literature and future research directions.¹ The role of bibliometric analysis in academic medicine is expected to grow with time.⁴

The most-cited articles in radiology or radiology subspecialties have been collected many times for

publication.⁵⁻¹⁸ Also, many of the 100 most-cited articles in radiology or radiology journals are found through a simple search.^{5,6,11,14-17} Some of these studies focused solely on the top 100 cited articles in radiology.^{5,11,14} These employed different methods to compile their citation list, yet there was a significant overlap in their final compilation.^{5,11,14} All three studies restricted their literature search to radiology-specific journals and cited it as a limitation.^{5,11,14}

Our literature search did not reveal bibliometric analyses of the 100 most-cited articles in CT colonography (CTC). These focused bibliometric analyses have implications for clinical radiologists and researchers examining recent trends in publications on a specific entity.

The purpose of this study was to recognize and examine the top 100 cited articles in which CTC was used across all peer-reviewed scientific journals. We included CTC articles published in non-radiology journals including but

not limited to the *New England Journal of Medicine*, *Lancet* and *JAMA*, creating a comprehensive database of the most influential articles that utilize this imaging technique. This paper identifies the most influential publications and authors to date in CTC, while also recognizing current and future research directions.

METHODS AND MATERIALS

To conduct a bibliometric analysis of the most highly cited articles in CTC, we performed a search of Thomson Reuters' Web of Science (WOS) All Databases on 25 July 2016, which indexed over 12,000 of the most-cited journals in the world. All journals in the search engine were included regardless of country of origin or medical specialty. We used the following search phrase in a "topic" search, without restriction of language or publication year:

- (Computed Colonography) OR (Computed Colonoscopy) OR (Computed Colography) OR (Computed Coloscopy).
- OR (Virtual Colonography) OR (Virtual Colonoscopy) OR (Virtual Colography) OR (Virtual Coloscopy).
- OR (Computed Tomographic Colonography) OR (Computed Tomographic Colonoscopy) OR (Computed Tomographic Colography) OR (Computed Tomographic Coloscopy).
- OR (CT Colonography) OR (CT Colonoscopy) OR (CT Colography) OR (CT Coloscopy).

A total of 10,597 articles were returned from this search, and included all articles in our search, regardless of language. Once the results were compiled, a single list was created which ranked articles from most to least cited. Beginning with the most highly cited article, each publication was assessed for inclusion. Articles were included if they focused on diagnostic imaging outcome/interpretation (comparison with another modality, sensitivity/specificity/PPV/NPV), CTC imaging technique, cost effectiveness analysis, clinical use of CTC, patient preference or trends in CTC. Articles were excluded if they did not pertain to CTC, or explored laboratory or basic science research.

We then compiled the most-cited articles into a single database. Citation count was acquired from WOS, WOS core collection and Scopus. In case of occasional variability in the citation counts we used WOS, which has shown most reliable for clinical medicine.^{2,19,20} The database included: WOS citations, citations per year, year published, journal, authors, department affiliation, study type and design, statistical analysis, sample size, modality and topic, with WOS providing the reference source for our chosen metrics in case of discrepancies with Scopus®. Impact factors for journals were determined from Thomson Reuters Journal Citation Reports issued in 2015.

RESULTS

Citations for the top 100 articles ranged from 73 to 1179 with a median of 120.5. These results are displayed below in [Table 1](#).

Citations per year

Citations per year ranged from 4.5 per year to 84.21 per year with a median of 8.28 citations per year. A list of the top

20 articles with most number of citations per year is given in [Table 2](#).

Year of publication

These articles were published between 1996 and 2012. The median was found to be 2003. Most of the articles were published in the 2000's. [Figure 1](#) is a graphical representation of the distribution of the top 100 cited articles by a 5-year span of publication.

Most common authors and number of authors

The total number of authors for the 100 most-cited works was noted to be 432, not including any research groups listed. Of these 432 authors, 60 had contributed to two articles each and a total of 312 authors had contributed to a single article.

Number of authors listed for any single publication ranged from 1 to 25. Most frequently 6 to 10 ($n = 52$) authored an article. This was followed by 1–5 ($n = 36$), 11 to 15 ($n = 5$) authors and 16 or more authors ($n = 7$). Mode and median were determined to be six authors. Authors contributed from 1 to 20 articles. [Table 3](#) displays authors who contributed to more than five of the top 100 list. It also indicates these authors' total contribution to the field of CTC imaging.

Departmental affiliation

Departmental affiliations of first authors totalled eight different fields and are presented in [Table 4](#). Departmental affiliation was most frequently radiology ($n = 81$), followed by gastroenterology ($n = 9$) and internal medicine ($n = 6$).

Journals

22 journals have published these 100 most-cited articles. A list of top journals including impact factor is given in [Table 5](#). The remainder of the journals published one article each of the most-cited works.

Design and analyses

Study design was primarily prospective ($n = 57$), followed by retrospective ($n = 28$) and randomized controlled trials ($n = 5$). The remaining 10 papers were reviews. These results are displayed in [Table 6](#). Statistical analysis was done in 86 of these articles. Of the 14 without analyses done, 6 were retrospective studies, 4 were reviews and 4 were prospective.

Sample size

Sample size, or human patient numbers for the articles is presented in [Figure 2](#). Median sample size was 165. Sample size was not stated for 15 articles.

Country of origin

Most of the papers were published from the USA ($n = 72$), followed by Italy ($n = 7$) and England ($n = 7$). The results are displayed in entirety below in [Table 7](#).

Number of institutions

Number of affiliated institutions with each publication ranged from 1 to 19. Most frequently one ($n = 51$) or two ($n = 21$)

Table 1. The 100 top-cited articles in CTC GI imaging ranked in descending order of number of citations

Rank	Article	Citations
1.	Pickhardt PJ, Choi JR, Hwang I, Butler JA, Puckett ML, Hildebrandt HA, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. <i>N Engl J Med</i> 2003; 349 (23): 2191–2200doi:10.1056/NEJMoa031618	1179
2.	Fenlon HM, Nunes DP, Schroy PC, Barish MA, Clarke PD, Ferrucci JT. A comparison of virtual and conventional colonoscopy for the detection of colorectal polyps. <i>N Engl J Med</i> 1999; 341 (20): 1496–1503. doi:10.1056/nejm19991113412003	515
3.	Johnson CD, Chen MH, Toledano AY, Heiken JP, Dachman A, Kuo MD, et al. Accuracy of CT colonography for detection of large adenomas and cancers. <i>N Engl J Med</i> 2008; 359 (12): 1207–1217doi:10.1056/NEJMoa0800996	498
4.	Cotton PB, Durkalski VL, Benoit PC, Palesch YY, Mauldin PD, Hoffman B, et al. Computed tomographic colonography (virtual colonoscopy) - A multicenter comparison with standard colonoscopy for detection of colorectal neoplasia. <i>J Am Med Assoc</i> 2004; 291 (14): 1713–1719. doi:10.1001/jama.291.14.1713	445
5.	Rockey DC, Poulson E, Niedzwiecki D, Davis W, Bosworth HB, Sanders L, et al. Analysis of air contrast barium enema computed tomographic colonography, and colonoscopy: prospective comparison. <i>Lancet</i> 2005; 365 (9456): 305–311.	372
6.	Yee J, Akerkar GA, Hung RK, Steinauer-Gebauer AM, Wall SD, McQuaid KR. Colorectal neoplasia: performance characteristics of CT colonography for detection in 300 patients. <i>Radiology</i> 2001; 219 (3): 685–692.	360
7.	Kim DH, Pickhardt PJ, Taylor AJ, Leung WK, Winter TC, Hinshaw JL, et al. CT colonography versus colonoscopy for the detection of advanced neoplasia. <i>N Engl J Med</i> 2007 357 (14): 1403–1412. doi:10.1056/NEJMoa070543	353
8.	Zalis ME, Barish MA, Choi JR, Dachman AH, Fenlon HM, Ferrucci JT, et al. CT colonography reporting and data system: a consensus proposal. <i>Radiology</i> 2005; 236 (1): 3–9. doi:10.1148/radiol.2361041926	321
9.	Fletcher JG, Johnson CD, Welch TJ, MacCarty RL, Ahlquist DA, Reed JE, et al. Optimization of CT colonography technique: prospective trial in 180 patients. <i>Radiology</i> 2000; 216 (3): 704–711.	243
10.	Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, MacCarty RL, et al. Detection of colorectal polyps with CT colography: initial assessment of sensitivity and specificity. <i>Radiology</i> 1997; 205 (1): 59–65.	240
11.	Johnson CD, Harmsen WS, Wilson LA, MacCarty RL, Welch TJ, Ilstrup DM, et al. Prospective blinded evaluation of computed tomographic colonography for screen detection of colorectal polyps. <i>Gastroenterology</i> 2003; 125 (2): 311–319. doi:10.1016/s0016-5085(03)00894-1	240
12.	Yoshida H, Nappi J. Three-dimensional computer-aided diagnosis scheme for detection of colonic polyps. <i>IEEE Trans Med Imag</i> 2001; 20 (12): 1261–1274. doi:10.1109/42.974921	225
13.	Mulhall BP, Veerappan GR, Jackson JL. Meta-analysis: computed tomographic colonography. <i>Ann Intern Med</i> 2005; 142 (8): 635–650.	218
14.	Hara AK, Johnson CD, MacCarty RL, Welch TJ. Incidental extracolonic findings at CT colonography. <i>Radiology</i> 2000; 215 (2): 353–357.	213
15.	Halligan S, Altman DG, Taylor SA, Mallett S, Deeks JJ, Bartram CI, et al. CT colonography in the detection of colorectal polyps and cancer: systematic review meta-analysis and proposed minimum data set for study level reporting. <i>Radiology</i> 2005; 237 (3): 893–904. doi:10.1148/radiol.2373050176	210
16.	Dachman AH, Kuniyoshi JK, Boyle CM, Samara Y, Hoffmann KR, Rubin DT, et al. CT colonography with three-dimensional problem solving for detection of colonic polyps. <i>Am J Roentgenol</i> 1998; 171 (4): 989–995.	208
17.	Summers RM, Johnson CD, Pusanik LM, Malley JD, Youssef AM, Reed JE. Automated polyp detection at CT colonography: feasibility assessment in a human population. <i>Radiology</i> 2001; 219 (1): 51–59.	196
18.	Gluecker TM, Johnson CD, Harmsen WS, Offord KP, Harris AM, Wilson LA, et al. Colorectal cancer screening with CT colonography, colonoscopy, and double-contrast barium enema examination: prospective assessment of patient perceptions and preferences. <i>Radiology</i> 2003; 227 (2): 378–384. doi:10.1148/radiol.2272020293	195
19.	Lefere P, Gryspeerd S, Marrannes J, Baekelandt M, Van Holsbeeck B. CT colonography after fecal tagging with a reduced cathartic cleansing and a reduced volume of barium. <i>American Journal of Roentgenology</i> 2005; 184 (6): 1836–1842.	191
20.	Iannaccone R, Laghi A, Catalano C, Mangiapane F, Lamazza A, Schillaci A, et al. Computed tomographic colonography without cathartic preparation for the detection of colorectal polyps. <i>Gastroenterology</i> 2004; 127 (5): 1300–1311doi:10.1053/j.gastro.2004.08.025	186
21.	Callstrom MR, Johnson CD, Fletcher JG, Reed JE, Ahlquist DA, Harmsen WS, et al. CT colonography without cathartic preparation: feasibility study. <i>Radiology</i> 2001; 219 (3): 693–698.	182
22.	Fenlon HM, McAneny DB, Nunes DP, Clarke PD, Ferrucci JT. Occlusive colon carcinoma: Virtual colonoscopy in the preoperative evaluation of the proximal colon. <i>Radiology</i> 1999; 210 (2): 423–428.	179
23.	Graser A, Stieber P, Nagel D, Schafer C, Horst D, Becker CR, et al. Comparison of CT colonography colonoscopy, sigmoidoscopy and faecal occult blood tests for the detection of advanced adenoma in an average risk population. <i>Gut</i> 2009; 58 (2): 241–248. doi:10.1136/gut.2008.156448	179

(Continued)

Table 1. (Continued)

Rank	Article	Citations
24.	Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, et al. Detection of colorectal polyps by computed tomographic colography: feasibility of a novel technique. <i>Gastroenterology</i> 1996; 110 (1): 284–290. doi:10.1053/gast.1996.v110.pm8536869	176
25.	Summers RM, Beaulieu CF, Pusanik LM, Malley JD, Jeffrey RB, Glazer DI, et al. Automated polyp detector for CT colonography: feasibility study. <i>Radiology</i> 2000; 216 (1): 284–290.	174
26.	Summers RM, Yao JH, Pickhardt PJ, Franaszek M, Bitter I, Brickman D, et al. Computed tomographic virtual colonoscopy computer-aided polyp detection in a screening population. <i>Gastroenterology</i> 2005; 129 (6): 1832–1844. doi:10.1053/j.gastro.2005.08.054	173
27.	Johnson CD, Dachman AH. CT colonography: the next colon screening examination? <i>Radiology</i> 2000; 216 (2): 331–341.	172
28.	Hara AK, Johnson CD, Reed JE, Ehman RL, Ilstrup DM. Colorectal polyp detection with CT colography: two- versus three-dimensional techniques - Work in progress. <i>Radiology</i> 1996; 200 (1): 49–54.	170
29.	Yoshida H, Nappi J, MacEneaney P, Rubin DT, Dachman AH. Computer-aided diagnosis scheme for detection of polyps at CT colonography. <i>Radiographics</i> 2002; 22 (4): 963–979.	160
30.	Svensson MH, Svensson E, Lasso A, Hellstrom M. Patient acceptance of CT colonography and conventional colonoscopy: Prospective comparative study in patients with or suspected of having colorectal disease. <i>Radiology</i> 2002; 222 (2): 337–345. doi:10.1148/radiol.2222010669	158
31.	Chen SC, Lu DSK, Hecht JR, Kadell BM. CT colonography: value of scanning in both the supine and prone positions. <i>Am J Roentgenol</i> 1999; 172 (3): 595–599.	152
32.	Sonnenberg A, Delco F, Bauerfeind P. Ts virtual colonoscopy a cost-effective option to screen for colorectal cancer? <i>Am J Gastroenterol</i> 1999; 94 (8): 2268–2274.	152
33.	Macari M, Bini EJ, Xue XN, Milano A, Katz SS, Resnick D, et al. Colorectal neoplasms: prospective comparison of thin-section low-dose multi-detector row CT colonography and conventional colonoscopy for detection. <i>Radiology</i> 2002; 224 (2): 383–392. doi:10.1148/radiol.2242011382	149
34.	Gluecker TM, Johnson CD, Wilson LA, MacCarty RL, Welch TJ, Vanness DJ, Ahlquist DA. Extracolonic findings at CT colonography: Evaluation of prevalence and cost in a screening population. <i>Gastroenterology</i> 2003; 124 (4): 911–916. doi:10.1053/gast.2003.50158	148
35.	Paik DS, Beaulieu CF, Rubin GD, Acar B, Jeffrey RB, Yee J, et al. Surface normal overlap: A computer-aided detection algorithm with application to colorectal polyps and lung nodules in helical CT. <i>IEEE Trans Med Imag</i> 2004; 23 (6): 661–675. doi:10.1109/tmi.2004.826362	147
36.	Lieberman D, Nadel M, Smith RA, Atkin W, Duggirala SB, Fletcher R, et al. Standardized colonoscopy reporting and data system: report of the Quality Assurance Task Group of the National Colorectal Cancer Roundtable. <i>Gastrointest Endosc</i> 2007; 65 (6): 757–766. doi:10.1016/j.gie.2006.12.055	146
37.	Royster AP, Fenlon HM, Clarke PD, Nunes DP, Ferrucci JT. CT colonoscopy of colorectal neoplasms: two-dimensional and three-dimensional virtual-reality techniques with colonoscopic correlation. <i>Am J Roentgenol</i> 1997; 169 (5): 1237–1242.	146
38.	Rex DK, Vining D, Kopecky KK. An initial experience with screening for colon polyps using spiral CT with and without CT colography (virtual colonoscopy). <i>Gastrointest Endosc</i> 1999; 50 (3): 309–313. doi:10.1053/ge.1999.v50.97776	141
39.	Morrin MM, Kruskal JB, Farrell RJ, Goldberg SN, McGee JB, Raptopoulos V. Endoluminal CT colonography after an incomplete endoscopic colonoscopy. <i>Am J Roentgenol</i> 1999; 172 (4): 913–918.	136
40.	Brenner DJ, Georgsson MA. Mass screening with CT colonography: Should the radiation exposure be of concern? <i>Gastroenterology</i> 2005; 129 (1): 328–337. doi:10.1053/j.gastro.2005.05.021	135
41.	Ristvedt SL, McFarland EG, Weinstock LB, Thyssen EP. Patient preferences for CT colonography conventional colonoscopy and bowel preparation. <i>Am J Gastroenterol</i> 2003; 98 (3): 578–585. doi:10.1016/s0002-9270(02)06024-0	133
42.	Macari M, Milano A, Lavelle M, Berman P, Megibow AJ. Comparison of time-efficient CT colonography with two- and three-dimensional colonic evaluation for detecting colorectal polyps. <i>Am J Roentgenol</i> 2000; 174 (6): 1543–1549.	129
43.	Morrin MM, Farrell RJ, Kruskal JB, Reynolds K, McGee JB, Raptopoulos V. Utility of intravenously administered contrast material at CT colonography. <i>Radiology</i> 2000; 217 (3): 765–771.	129
44.	Pineau BC, Paskett ED, Chen GJ, Espeland MA, Phillips K, Han JP, et al. Virtual colonoscopy using oral contrast compared with colonoscopy for the detection of patients with colorectal polyps. <i>Gastroenterology</i> 2003; 125 (2): 304–310. doi:10.1016/s0016-5085(03)00885-0	127
45.	Hara AK, Johnson CD, MacCarty RL, Welch TJ, McCollough CH, Harmen WS. CT colonography: single-versus multi-detector row imaging. <i>Radiology</i> 2001; 219 (2): 461–465.	125

(Continued)

Table 1. (Continued)

Rank	Article	Citations
46.	Van Gelder RE, Nio CY, Florie J, Bartelsman JF, Snel P, De Jager SW, et al. Computed tomographic colonography compared with colonoscopy in patients at increased risk for colorectal cancer. <i>Gastroenterology</i> 2004; 127 (1): 41–48. doi:10.1053/j.gastro.2004.03.055	124
47.	Flicek KT, Hara AK, Silva AC, Wu Q, Peter MB, Johnson CD. Reducing the radiation dose for CT colonography using adaptive statistical iterative reconstruction: A pilot study. <i>Am J Roentgenol</i> 2010; 195 (1): 126–131. doi:10.2214/ajr.09.3855	122
48.	Pickhardt PJ, Choi JHR. Electronic cleansing and stool tagging in CT colonography: Advantages and pitfalls with primary three-dimensional evaluation. <i>Am J Roentgenol</i> 2003; 181 (3): 799–805.	122
49.	Pickhardt PJ, Hassan C, Laghi A, Zullo A, Kim DH, Morini S. Cost-effectiveness of colorectal cancer screening with computed tomography colonography - The impact of not reporting diminutive lesions. <i>Cancer</i> 2007; 109 (11): 2213–2221doi:10.1002/cncr.22668	121
50.	van Gelder RE, Venema HW, Serlie IWO, Nio CY, Determann RM, Tipker CA, et al. CT colonography at different radiation dose levels: Feasibility of dose reduction. <i>Radiology</i> 2002; 224 (1): 25–33. doi:10.1148/radiol.2241011126	121
51.	Macari M, Berman P, Dicker M, Milano A, Megibow AJ. Usefulness of CT colonography in patients with incomplete colonoscopy. <i>Am J Roentgenol</i> 1999; 173 (3): 561–564.	120
52.	Hara AK, Johnson CD, Reed JE, Ahlquist DA, Nelson H, Ehman RL, Harmsen WS. Reducing data size and radiation dose for CT colonography. <i>Am J Roentgenol</i> 1997; 168 (5): 1181–1184.	116
53.	Regge D, Laudi C, Galatola G, Della Monica P, Bonelli L, Angelelli G, et al. Diagnostic accuracy of computed tomographic colonography for the detection of advanced neoplasia in individuals at increased risk of colorectal cancer. <i>J Am Med Assoc</i> 2009; 301 (23): 2453–2461.	115
54.	Pickhardt PJ, Hassan C, Halligan S, Marmo R. Colorectal Cancer: CT colonography and colonoscopy for detection-systematic review and meta-analysis. <i>Radiology</i> 2011; 259 (2): 393–405. doi:10.1148/radiol.11101887	113
55.	Neri E, Giusti P, Battolla L, Vagli P, Boraschi P, Lencioni R, et al. Colorectal cancer: Role of CT colonography in preoperative evaluation after incomplete colonoscopy. <i>Radiology</i> 2002; 223 (3): 615–619. doi:10.1148/radiol.2233010928	111
56.	Spinzi G, Belloni G, Martegani A, Sangiovanni A, Del Favero C, Minoli G. Computed tomographic colonography and conventional colonoscopy for colon diseases: a prospective blinded study. <i>Am J Gastroenterol</i> 2001; 96 (2): 394–400.	111
57.	Stoop EM, de Haan MC, de Wijkerslooth TR, Bossuyt PM, van Ballegooijen M, Nio CY, et al. Participation and yield of colonoscopy versus non-cathartic CT colonography in population-based screening for colorectal cancer: a randomised controlled trial. <i>Lancet Oncol</i> 2012; 13 (1): 55–64. doi:10.1016/s1470-2045(11)70283-2	109
58.	Taylor SA, Laghi A, Lefere P, Halligan S, Stoker J. European society of gastrointestinal and abdominal radiology (ESGAR): Consensus statement on CT colonography. <i>Eur Radiol</i> 2007; 17 (2): 575–579. doi:10.1007/s00330-006-0407-y	108
59.	Sosna J, Morrin MM, Kruskal JB, Lavin PT, Rosen MP, Raptopoulos V. CT Colonography of colorectal polyps: a metaanalysis <i>Am J Roentgenol</i> 2003; 181 (6): 1593–1598.	106
60.	Macari M, Lavelle M, Pedrosa I, Milano A, Dicker M, Megibow AJ, Xue XN. Effect of different bowel preparations on residual fluid at CT colonography. <i>Radiology</i> 2001; 218 (1): 274–277.	105
61.	Summers RM, Jerebko AK, Franaszek M, Malley JD, Johnson CD. Colonic polyps: Complementary role of computer-aided detection in CT Colonography. <i>Radiology</i> 2002; 225 (2): 391–399. doi:10.1148/radiol.2252011619	104
62.	Taylor SA, Halligan S, Goh V, Morley S, Bassett P, Atkin W, Bartram CI. Optimizing colonic distention for multi-detector row CT colonography: effect of hyoscine butylbromide and rectal balloon catheter. <i>Radiology</i> 2003; 229 (1): 99–108. doi:10.1148/radiol.2291021151	104
63.	Burling D, Halligan S, Slater A, Noakes MJ, Taylor SA. Potentially serious adverse events at CT colonography in symptomatic patients: National survey of the United Kingdom. <i>Radiology</i> 2006; 239 (2): 464–471. doi:10.1148/radiol.2392051101	103
64.	Gokturk SB, Tomasi C, Acar B, Beaulieu CF, Paik DS, Jeffrey RB, et al. A statistical 3-D pattern processing method for computer-aided detection of polyps in CT colonography. <i>IEEE Trans Med Imag</i> 2001; 20 (12): 1251–1260. doi:10.1109/42.974920	101
65.	Zalis ME, Hahn PF. Technical innovationDigital subtraction bower cleansing in CT colonography <i>Am J Roentgenol</i> 2001; 176 (3): 646–648.	101
66.	Fidler JL, Johnson CD, MacCarty RL, Welch TJ, Hara AK, Harmsen WS. Detection of flat lesions in the colon with CT colonography. <i>Abdom Imaging</i> 2002; 27 (3): 292–300. doi:10.1007/s00261-001-0171-z	100
67.	Filippone A, Ambrosini R, Fuschi M, Marinelli T, Genovesi D, Bonomo L. Preoperative T and N staging of colorectal cancer: accuracy of contrast-enhanced multi-detector row CT colonography - Initial experience. <i>Radiology</i> 2004; 231 (1): 83–90. doi:10.1148/radiol.2311021152	99
68.	Pickhardt PJ, Hanson ME, Vanness DJ, Lo JY, Kim DH, Taylor AJ, et al. Unsuspected extracolonic findings at screening CT colonography: clinical and economic impact. <i>Radiology</i> 2008; 249 (1): 151–159. doi:10.1148/radiol.2491072148	98

(Continued)

Table 1. (Continued)

Rank	Article	Citations
69.	Pickhardt PJ. Incidence of colonic perforation at CT colonography: Review of existing data and implications for screening of asymptomatic adults. <i>Radiology</i> 2006; 239 (2): 313–316. doi:10.1148/radiol.2392052002	97
70.	van Gelder RE, Birnie E, Florie J, Schutter MP, Bartelsman JF, Snel P, et al. CT colonography and colonoscopy: assessment of patient preference in a 5 week follow-up study. <i>Radiology</i> 2004; 233 (2): 328–337. doi:10.1148/radiol.2331031208	97
71.	Pickhardt PJ, Nugent PA, Choi JR, Schindler WR. Flat colorectal lesions in asymptomatic adults: Implications for screening with CT virtual colonoscopy. <i>Am J Roentgenol</i> 2004; 183 (5): 1343–1347.	96
72.	Taylor SA, Halligan S, Saunders BP, Bassett P, Vance M, Bartram CI. Acceptance by patients of multidetector CT colonography compared with barium enema examinations flexible sigmoidoscopy, and Colonoscopy. <i>Am J Roentgenol</i> 2003; 181 (4): 913–921.	96
73.	Yee J, Kumar NN, Hung RK, Akerkar GA, Kumar PRG, Wall SD. Comparison of supine and prone scanning separately and in combination at CT colonography. <i>Radiology</i> 2003; 226 (3): 653–661. doi:10.1148/radiol.2263010701	94
74.	Yee J, Hung RK, Akerkar GA, Wall SD. The usefulness of glucagon hydrochloride for colonic distention in CT colonography. <i>Am J Roentgenol</i> 1999; 173 (1): 169–172.	93
75.	Iannaccone R, Laghi A, Catalano C, Brink JA, Mangiapane F, Trenna S, et al. Detection of colorectal lesions: lower-dose multi-detector row helical CT colonograph compared with conventional colonoscopy. <i>Radiology</i> 2003; 229 (3): 775–781. doi:10.1148/radiol.2293021399	92
76.	Beaulieu CE, Jeffrey RB, Karadi C, Paik DS, Napel S. Display modes for CT colonography - Part II Blinded comparison of axial CT and virtual endoscopic and panoramic endoscopic volume-rendered studies. <i>Radiology</i> 1999; 212 (1): 203–212.	90
77.	Sosna J, Blachar A, Amitai M, Barmer E, Peled N, Goldberg SN, Ziv JB. Colonic perforation at CT colonography: Assessment of risk in a multicenter large cohort. <i>Radiology</i> 2006; 239 (2): 457–463. doi:10.1148/radiol.2392050287	90
78.	Ferrucci JT. Colon cancer screening with virtual colonoscopy: Promise polyps politics. <i>Am J Roentgenol</i> 2001; 177 (5): 975–988.	89
79.	Yee J, Kumar NN, Godara S, Casamina JA, Hom R, Galdino G, et al. Extracolonic abnormalities discovered incidentally at CT colonography in a male population. <i>Radiology</i> 2005; 236 (2): 519–526. doi:10.1148/radiol.2362040166	89
80.	Hellstrom M, Svensson MH, Lasso A. Extracolonic and incidental findings on CT colonography (virtual colonoscopy) <i>Am J Roentgenol</i> 2004; 182 (3): 631–638.	88
81.	Yoshida H, Masutani Y, MacEneaney P, Rubin DT, Dachman AH. Computerized detection of colonic polyps at CT colonography on the basis of volumetric features: Pilot study. <i>Radiology</i> 2002; 222 (2): 327–336. doi:10.1148/radiol.2222010506	88
82.	Akerkar GA, Yee J, Hung R, McQuaid K. Patient experience and preferences toward colon cancer screening: a comparison of virtual colonoscopy and conventional colonoscopy. <i>Gastrointest Endosc</i> 2001; 54 (3): 310–315. doi:10.1067/mge.2001.117595	87
83.	Chen DQ, Liang ZR, Wax MR, Li LH, Li B, Kaufman AE. A novel approach to extract colon lumen from CT images for virtual colonoscopy. <i>IEEE Trans Med Imag</i> . 2000; 19 (12): 1220–1226. doi:10.1109/42.897814	87
84.	Halligan S, Altman DG, Mallett S, Taylor SA, Burling D, Roddie M, et al. Computed tomographic colonography: Assessment of radiologist performance with and without computer-aided detection. <i>Gastroenterology</i> 2006; 131 (6): 1690–1699. doi:10.1053/j.gastro.2006.09.051	87
85.	Hassan C, Pickhardt P, Laghi A, Kim D, Zullo A, Iafrate F, et al. Computed tomographic colonography to screen for colorectal cancer extracolonic cancer, and aortic aneurysm. <i>Arch Intern Med</i> 2008; 168 (7): 696–705. doi:10.1001/archinte.168.7.696	87
86.	Kiss G, Van Cleynenbreugel J, Thomeer M, Suetens P, Marchal G. Computer-aided diagnosis in virtual colonography via combination of surface normal and sphere fitting methods. <i>Eur Radiol</i> 2002; 12 (1): 77–81. doi:10.1007/s003300101040	87
87.	Morrin MM, Farrell RJ, Raptopoulos V, McGee JB, Bleday R, Kruskal JB. Role of virtual computed tomographic colonography in patients with colorectal cancers and obstructing colorectal lesions. <i>Dis Colon Rectum</i> 2000; 43 (3): 303–311. doi:10.1007/bf02258293	87
88.	Pickhardt PJ, Taylor AJ, Kim DH, Reichelderfer M, Gopal DV, Pfau PR. Screening for colorectal neoplasia with CT colonography: initial experience from the 1 st year of coverage by third-party payers. <i>Radiology</i> 2006; 241 (2): 417–425. doi:10.1148/radiol.2412052007	86
89.	Pescatore P, Glicker T, Delarive J, Meuli R, Pantoflickova D, Duvoisin B, et al. Diagnostic accuracy and interobserver agreement of CT colonography (virtual colonoscopy). <i>Gut</i> 2000; 47 (1): 126–130. doi:10.1136/gut.47.1.126	85
90.	Johnson CD, Toledano AY, Herman BA, Dachman AH, McFarland EG, Barish MA, et al. Computerized tomographic colonography: performance evaluation in a retrospective multicenter setting. <i>Gastroenterology</i> 2003; 125 (3): 688–695. doi:10.1016/s0016-5085(03)01058-8	83
91.	Zalis ME, Perumpillichira J, Del Frate C, Hahn PF. CT colonography: digital subtraction bowel cleansing with mucosal reconstruction - Initial observations. <i>Radiology</i> 2003; 226 (3): 911–917. doi:10.1148/radiol.2263012059	83
92.	Fletcher JG, Johnson CD, MacCarty RL, Welch TJ, Reed JE, Hara AK. CT colonography: potential pitfalls and problem-solving techniques. <i>Am J Roentgenol</i> 1999; 172 (5): 1271–1278.	81

(Continued)

Table 1. (Continued)

Rank	Article	Citations
93.	Taylor SA, Halligan S, Burling D, Morley S, Bassett P, Atkin W, Bartram CI. CT colonography: effect of experience and training on reader performance. <i>Eur Radiol</i> 2004; 14 (6): 1025–1033. doi:10.1007/s00330-004-2262-z	79
94.	Vijan S, Hwang I, Inadomi J, Wong RKH, Choi JR, Napierkowski J, et al. The cost-effectiveness of CT colonography in screening for colorectal neoplasia <i>Am J Gastroenterol</i> 2007; 102 (2): 380–390 doi:10.1111/j.1572-0241.2006.00970.x	78
95.	Ladabaum U, Song K, Fendrick AM. Colorectal Neoplasia Screening With Virtual Colonoscopy: When at What Cost and With What National Impact? <i>Clin Gastroenterol Hepatol</i> 2004; 2 (7): 554–563. doi:10.1053/s1542-3565(04)00247-2	77
96.	Lefere PA, Gryspeerdt SS, Dewyspelaere J, Baekelandt M, Van Holsbeeck BG. Dietary fecal tagging as a cleansing method before CT colonography: Initial results-polyp detection and patient acceptance. <i>Radiology</i> 2002; 224 (2): 393–403. doi:10.1148/radiol.2241011222	76
97.	Thomeer M, Bielen D, Vanbeckevoort D, Dymarkowski S, Gevers A, Rutgeerts P, et al. Patient acceptance for CT colonography: what is the real issue? <i>Eur Radiol</i> 2002; 12 (6): 1410–1415. doi:10.1007/s003300101082	76
98.	Wan M, Liang ZR, Ke Q, Hong LC, Bitter I, Kaufman A. Automatic centerline extraction for virtual colonoscopy. <i>IEEE Trans Med Imag</i> 2002; 21 (12): 1450–1460. doi:10.1109/tmi.2002.806409	76
99.	Laghi A, Iannaccone R, Carbone I, Catalano C, Di Giulio E, Schillaci A, Passariello R. Detection of colorectal lesions with virtual computed tomographic colonography. <i>Am J Surg</i> 2002 183 (2): 124–131. doi:10.1016/s0002-9610(01)00857-1	74
100.	Shinners TJ, Pickhardt PJ, Taylor AJ, Jones DA, Olsen CH. Patient-controlled room air insufflation versus automated carbon dioxide delivery for CT colonography. <i>Am J Roentgenol</i> 2006; 186 (6): 1491–1496. doi:10.2214/ajr.05.0416	73

institutions were listed. These results are displayed in more detail in [Table 8](#). Of the top 100 articles, 77 were affiliated with more than one department and 21 were affiliated with more than one hospital.

Topics

Each article was evaluated for its primary topic/objective. Of these 100 most-cited CTC articles, 40 focused on CTC imaging technique and 28 covered diagnostic utility of an imaging modality (comparison with another modality, sensitivity/specificity/PPV/NPV). Clinical uses of CTC were covered in 18 articles. Patient preference and perception of CTC was covered in seven papers, economic impact/cost-effective analyses of CTC as a screening tool was covered in five papers and two articles covered multiple topics.

DISCUSSION

Our analysis revealed that the most-cited article in CTC is the 2003 paper by Pickhardt et al “Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults,” published in *The New England Journal of Medicine*. It was also the article with the most citations per year since publication, with 84.21 average citations per year. 63 of the 100 most-cited articles were published before 2005, biasing the list in favour of articles that have had longer periods of time since publication to accumulate citations. Therefore, we also included the measure of citations per year. The advantage of using citations per year is that it corrects the total citations for time since publication.

Careful interrogation of the content of top articles brought forth several noteworthy findings, *i.e.* we noted that of the top three articles, which are garnering the most citations per year, two are related to diagnostic outcomes and one is in regard to screening ([Table 1](#)). We feel that this could be because in modern medicine, there is more interest in sensible

application of imaging and maximizing detection rates.^{21,22} Three articles described the significantly lower risk of severe complications, specifically perforation, during CTC when compared with optical colonoscopy. The works determined that the risk approached 0% in CTC. Old age and concomitant colorectal disease were noted to represent risk factors for perforation. Five articles demonstrate the distinct advantage of using CTC to detect clinically significant extracolonic findings such as abdominal aortic artery aneurysms or extracolonic malignancies. The average additional cost per patient ranged from \$28 to \$34. This point seemed quite contentious as the economic impact of these additional findings and subsequent investigations and/or management was unknown but CTC is still thought to be the safest and most cost-effective screening method especially with non-reporting of diminutive lesions and considering its ability to detect extracolonic findings.

The journal with the most publications was *Radiology* at 37. *American Journal of Roentgenology* was second with 19. Both journals reach a great number of medical practitioners, in particular radiologists. Behind these two journals was *Gastroenterology* with 10 articles. No other journals contributed more than five journals to the 100 most-cited list. This pattern of only a few journals predominating the top 100 citations is consistent with previously compiled bibliometric analyses.^{5,11,14–18} To our surprise, 25% of the top 100 articles had a sample size stated of less than or equal to 50. This could have significant impact for future studies in CTC, as it could imply that having a large sample size is not necessary to have an impactful study, or it could imply that early, novel, small studies get cited a lot because they are first to report new data.

Upon analysing the yearly distribution of the most-cited CTC articles by topic, a few temporal trends were noted ([Figure 3](#)). The early years of CTC saw an abundance of articles describing technique, including dose optimization, patient preparation and

Table 2. Top 20 cited CTC articles in descending order of the most number of citations received per year

Rank	Article	Citations per year
1.	Pickhardt PJ, Choi JR, Hwang I, Butler JA, Puckett ML, Hildebrandt HA, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. <i>N Engl J Med</i> 2003; 349 (23): 2191–2200. doi:10.1056/NEJMoa031618	84.21
3.	Johnson CD, Chen MH, Toledano AY, Heiken JP, Dachman A, Kuo MD, et al. Accuracy of CT colonography for detection of large adenomas and cancers. <i>N Engl J Med</i> 2008; 359 (12): 1207–1217. doi:10.1056/NEJMoa0800996	55.33
7.	Kim DH, Pickhardt PJ, Taylor AJ, Leung WK, Winter TC, Hinshaw JL, et al. CT colonography versus colonoscopy for the detection of advanced neoplasia. <i>N Engl J Med</i> 2007; 357 (14): 1403–1412. doi:10.1056/NEJMoa070543	35.4
4.	Cotton PB, Durkalski VL, Benoit PC, Palesch YY, Mauldin PD, Hoffman B, et al. Computed tomographic colonography (virtual colonoscopy) - a multicenter comparison with standard colonoscopy for detection of colorectal neoplasia. <i>J Am Med Assoc</i> 2004; 291 (14): 1713–1719. doi:10.1001/jama.291.14.1713	34.23
5.	Rockey DC, Poulson E, Niedzwiecki D, Davis W, Bosworth HB, Sanders L, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. <i>Lancet</i> 2005; 365 (9456): 305–311.	31.08
2.	Fenlon HM, Nunes DP, Schroy PC, Barish MA, Clarke PD, Ferrucci JT. A comparison of virtual and conventional colonoscopy for the detection of colorectal polyps. <i>N Engl J Med</i> 1999; 341 (20): 1496–1503. doi:10.1056/nejm199911113412003.	28.61
8.	Zalis ME, Barish MA, Choi JR, Dachman AH, Fenlon HM, Ferrucci JT, et al. CT colonography reporting and data system: A consensus proposal. <i>Radiology</i> 2005; 236 (1): 3–9. doi:10.1148/radiol.2361041926	26.75
6.	Yee J, Akerkar GA, Hung RK, Steinauer-Gebauer AM, Wall SD, McQuaid KR. Colorectal neoplasia, Performance characteristics of CT colonography for detection in 300 patients. <i>Radiology</i> 2001; 219 (3): 685–692.	22.5
22.	Graser A, Stieber P, Nagel D, Schafer C, Horst D, Becker CR, et al. Comparison of CT colonography, colonoscopy, sigmoidoscopy and faecal occult blood tests for the detection of advanced adenoma in an average risk population. <i>Gut</i> 2009; 58 (2): 241–248. doi:10.1136/gut.2008.156448	22.38
57.	Stoop EM, de Haan MC, de Wijkerslooth TR, Bossuyt PM, van Ballegooijen M, Nio CY, et al. Participation and yield of colonoscopy versus non-cathartic CT colonography in population-based screening for colorectal cancer: a randomised controlled trial. <i>Lancet Oncol</i> 2012; 13 (1): 55–64. doi:10.1016/s1470-2045(11)70283-2	22
54.	Pickhardt PJ, Hassan C, Halligan S, Marmo R. Colorectal cancer, CT colonography and colonoscopy for detection-systematic review and meta-analysis. <i>Radiology</i> 2011 259 (2): 393–405. doi:10.1148/radiol.11101887	18.83
13.	Mulhall BP, Veerappan GR, Jackson JL. Meta-analysis, Computed tomographic colonography. <i>Ann Intern Med</i> 2005 142 (8): 635–650.	18.17
15.	Halligan S, Altman DG, Taylor SA, Mallett S, Deeks JJ, Bartram CI, Atkin, W. CT colonography in the detection of colorectal polyps and cancer: systematic review meta-analysis and proposed minimum data set for study level reporting. <i>Radiology</i> 2005; 237 (3): 893–904. doi:10.1148/radiol.2373050176	17.5
47.	Flicek KT, Hara AK, Silva AC, Wu Q, Peter MB, Johnson CD. Reducing the radiation dose for CT colonography using adaptive statistical iterative reconstruction, A pilot study. <i>Am J Roentgenol</i> 2010; 195 (1): 126–131. doi:10.2214/ajr.09.3855	17.43
11.	Johnson CD, Harmsen WS, Wilson LA, MacCarty RL, Welch TJ, Ilstrup D. M. Prospective blinded evaluation of computed tomographic colonography for screen detection of colorectal polyps. <i>Gastroenterology</i> 2003; 125 (2): 311–319. doi:10.1016/s0016-5085(03)00894-1	17.14
36.	Lieberman D, Nadel M, Smith RA, Atkin W, Duggirala SB, Fletcher R, et al. Standardized colonoscopy reporting and data system: report of the Quality Assurance Task Group of the National Colorectal Cancer Roundtable. <i>Gastrointest Endosc</i> 2007; 65 (6): 757–766. doi:10.1016/j.gie.2006.12.055	14.6
26.	Summers RM, Yao JH, Pickhardt PJ, Franaszek M, Bitter I, Brickman D, et al. Computed tomographic virtual colonoscopy computer-aided polyp detection in a screening population. <i>Gastroenterology</i> 2005; 129 (6): 1832–1844. doi:10.1053/j.gastro.2005.08.054	14.42
53.	Regge D, Laudi C, Galatola G, Della Monica P, Bonelli L, Angelelli G, et al. Diagnostic accuracy of computed tomographic colonography for the detection of advanced neoplasia in individuals at increased risk of colorectal cancer. <i>J Am Med Assoc</i> 2009; 301 (23): 2453–2461.	14.38
20.	Iannaccone R, Laghi A, Catalano C, Mangiapane F, Lamazza A, Schillaci A, et al. Computed tomographic colonography without cathartic preparation for the detection of colorectal polyps. <i>Gastroenterology</i> 2004; 127 (5): 1300–1311. doi:10.1053/j.gastro.2004.08.025	14.31
9.	Fletcher JG, Johnson CD, Welch TJ, MacCarty RL, Ahlquist DA, Reed JE, et al. Optimization of CT colonography technique: Prospective trial in 180 patients. <i>Radiology</i> 2000; 216 (3): 704–711.	14.29

CTC, CT colonography.

positioning, image reconstruction and use of computer-aided detection. This then gave way to studies that compared CTC with established screening and imaging methods as well as the reliability and reproducibility of its results. This coincided with publications that analysed patients' perception and preference towards CTC. Following this, studies focused more on the clinical utility and implementation of CTC as well as establishing the best use-case scenarios and development of a standardized reporting

system. Finally, papers analysing the cost-effectiveness of CTC and the economic impact of this new modality began to appear, albeit in limited numbers. These trends generally follow what is expected when a new technique or technology is introduced from inception to dissemination and wide-spread adoption. Of note, studies which compared CTC with another imaging modality were the most regularly published throughout both early and late years of our analysis (1995–2013). We believe that this is the

Figure 1. Distribution of the 100 top-cited articles in CTC GI Imaging by 5-year span of publication. CTC, CT colonography; GI, gastrointestinal.

first bibliometric analysis focusing on CTC. Having a focused list can help radiologists and scientists by providing an accessible list of the most influential articles in CTC. The subspecialty analysis done also allows for a better understanding of what a highly cited work consists of, and where future research interests may lie. Understanding the composition of highly cited subspecialty works also allows editors and reviewers to evaluate unpublished articles. Niche bibliometric analysis such as ours in this paper has a stronger direct impact than general radiology lists, as most of radiology journals are subspecialty focused.

Table 3. Authors who contributed to more than five of the 100 top-cited articles in CTC GI Imaging

Author	# of articles in top 100	Total # of CTC/VC-related publications author has published
Johnson CD	20	67
Pickhardt PJ	13	188
Yee J	11	52
Hara AK	11	24
Maccarty RL	9	19
Halligan S	8	119
Laghi A	8	67
Ahlquist DA	8	25
Reed JE	8	10
Taylor SA	7	89
Harmsen WS	7	16
Welch TJ	7	11
Dachman AH	6	53
Macari M	6	25

Table 4. Departmental affiliations of authors of the 100 top-cited articles in CTC GI imaging

Departmental affiliation	Frequency (n)
Radiology	81
Gastroenterology	9
Internal medicine	6
Oncology	1
Psychiatry	1
Computer science	1
Electrical engineering	1

We noted that a large portion of prior bibliometric analysis done in radiology restricted their searches to only include radiology journals. As the role of radiology in patient-care grows, we felt that this was a significant limitation that excludes many relevant scientific journals. Radiology is intertwined in so many fields such as emergency medicine, trauma surgery, orthopedics, etc. which makes us feel that literature in those fields could be extremely relevant and important. This opinion prompted us to investigate the impact of works published in non-radiology journals on our analysis.

We established that 31% of the 100 top-cited CTC articles were published in non-radiology journals and 19% of the first authors had a departmental affiliation other than radiology. Studies that demonstrated that CTC was inferior to optical colonoscopy were exclusive to non-radiology journals. None of the journals that published cost-benefit analysis were radiology specific. Five of the highest cited papers on CTC discussed the economic impact of CTC, taking into consideration the additional extracolonic findings. Two of the five articles favoured economic savings over time by employing CTC as a screening

Table 5. Journals in which the 100 top-cited articles in CTC GI imaging were published

Journal	Frequency (n)	Impact factor
<i>Radiology</i>	37	6.867
<i>American Journal of Roentgenology</i>	19	2.73
<i>Gastroenterology</i>	10	16.716
<i>IEEE Transactions on Medical Imaging</i>	5	3.39
<i>New England Journal of Medicine</i>	4	55.873
<i>American Journal of Gastroenterology</i>	4	10.755
<i>European Radiology</i>	4	4.014
<i>Gastrointestinal Endoscopy</i>	3	5.369
<i>JAMA - Journal of the American Medical Association</i>	2	35.289
<i>GUT</i>	2	14.660

Table 6. Study design of 100 top-cited articles in CTC GI imaging

Study design	Frequency (n)
Prospective	57
Retrospective	28
Review paper	10
Randomized controlled trial	5

modality, whereas two others predicted an increase in overall cost by utilizing CTC as a screening modality. One article remained neutral and suggested further investigation into

Table 7. Country of first author for 100 top-cited articles in CTC GI imaging

Country of first author	Frequency (n)
USA	72
Italy	8
England	7
Belgium	4
Netherlands	4
Sweden	2
Germany	1
Israel	1
Switzerland	1

Table 8. Number of affiliated institutions per paper of 100 top-cited articles in CTC GI imaging

Number of affiliated institutions per paper	Frequency (n)
1	51
2	21
3–5	19
6–10	3
>10	6

the matter. Finally, both the top three cited papers, and the top-cited papers per year were published in the *New England Journal of Medicine*, not a radiology specific journal (Tables 1 and 2). The intertwined nature of radiology in modern medicine cannot be understated, and for this reason we strongly recommend that future studies, which focus on bibliometrics

Figure 2. Sample size of the 100 top-cited articles in CTC GI imaging.

Figure 3. Yearly distribution of most-cited CTC articles by topic. CTC, CT colonography.

in radiology should expand their inclusion criteria to include non-radiology journals.

LIMITATIONS

We are aware that our study being a bibliometric analysis by nature has limitations. The main limitation is the search terms, which were used to create the database. To be more specific, articles that did not use the term “gastrointestinal” did not appear in our database collection. We did not use the term “gut” instead of “gastrointestinal” because it created a wide-ranging list, which failed to capture many articles in our database. Similarly, our results were restricted to articles, which included “CTC”. As in other bibliometric analysis, we are aware that our list of articles is limited by the accuracy and inclusiveness of the keywords identified by the database.³

Citation counts from databases such as WOS, Scopus, Pubmed and Google Scholar often differ.^{2,5,16,17} We decided to use citation counts from WOS because we felt it was the most precise and accommodating with our search terms. One problem bibliometric analysis often face is that of the bias in favour of older publications.² For

this reason, we included the measure of citations per year to better identify publications with the most impact. Lastly, we found that our results had several articles which did not meet our final inclusion criteria, so we had two attending radiologists independently confirm article applicability.

CONCLUSION

Bibliometric analysis in academic medicine has enormous potential for future growth. Our study provides intellectual milestones in CTC research, reflecting on the characteristics and quality of published literature. Focused bibliometric analyses reveal characteristics of highly cited works. This information has implications for clinical radiologists, scientists, researchers and editors. Bibliometric analyses appraise us of the most influential articles of the current time and allow us to predict future trends in medical subspecialties.

DISCLOSURE

Faisal Khosa is the American Roentgen Ray Society Scholar (2013–2016). No financial disclosures or conflict of interest on behalf of the authors. There was no commercial funding for this study.

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