

Global trends of researches on radioactive enteritis

A bibliometric and visualization study

Daman Chen, BM^a, Kaibo Zhao, BM^b, Yongqi Guo, BS^b, Mingxin Dong, BM^b, Jiayi Cai, BS^b, Yingjia Zhou, PhD^{c,d}, Weibo Wen, PhD^e, Hongmei Shen, MM^{d,*} 

Abstract

Background: Radiation enteritis (RE) caused by radiation therapy, can seriously affect human health. Recently, studies on RE have been growing rapidly, but there are no bibliometric studies on RE. This study aims to explore the development trends and research hotspots of RE.

Methods: Academic papers on the Web of Science were retrieved on the topic of “radioactive enteritis” from the establishment of the database to December 2020. Countries, institutions, and subjects selected in this field were visualized using Citespace, HistCite, and Vosviewer. The annual trends in publications, distribution, co-authorship status, and research hotspots were analyzed.

Results: The authors ranked first in terms of publication amount were Delaney, Francois, Milliat, and Vozenin-Brotons. The United States had the highest number of posts, followed by China, France, the United Kingdom, and Spain.

Conclusion: Future research in the field of RE will focus on double-blind clinical trials of RE, and the related mechanisms, such as oxidative stress and apoptosis.

Abbreviations: RE = radiation enteritis, WOS = Web of Science.

Keywords: bibliometric analysis, radiation enteritis, research trends, visualization

1. Introduction

Radiation enteritis (RE) is an intestinal injury caused by radiotherapy for pelvic and abdominal malignant tumors.^[1,2] RE can be divided into acute and chronic RE according to the time of onset, and radiation small enteritis, colitis, and proctitis according to the site of the onset. Most of the clinical manifestations are abdominal pain, diarrhea, bloody stool, and even septicemia, multiple organ dysfunction syndrome, endangering the life of patients.^[3,4] The study found that >75% of patients with pelvic radiotherapy will develop acute proctitis and 5% to 20% of patients will develop chronic proctitis.^[5] At present, the main treatment of acute RE is symptomatic treatment, and chronic patients often need surgical treatment.^[6]

Citespace, HistCite, and Vosviewer are gradually developed citation visualization analysis software under the background of

data visualization. Through the analysis and integration of literature information, the 3 software use the “scientific knowledge graph” to present the basic knowledge, research progress, and research frontiers in a certain field.^[7–11] In this study, Citespace, HistCite, and Vosviewer were used to reveal the research progress and frontier of RE.

2. Materials and Methods

2.1. Data sources

We used the Web of Science (WOS) with *radiation enteritis* as the keywords to search articles from the establishment of the database to December 2020, without any restrictions on literature types and languages, and finally, 716 articles were included.

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The datasets generated during and/or analyzed during the current study are publicly available.

This is a review that does not require an ethics committee review board approval and informed consent.

The manuscript submitted does not contain information about medical device(s)/drug(s).

^a The Fourth Clinical Medical College of Guangzhou University of Chinese Medicine, Shenzhen, China, ^b Guangzhou University of Chinese Medicine, Guangzhou, China, ^c Nanjing University of Traditional Chinese Medicine, Nanjing, China, ^d Integrated Traditional Chinese and Western Medicine Department, Yunnan Cancer Hospital/the Third Affiliated Hospital of Kunming Medical University, Kunming, China, ^e Academic Affairs Department, Yunnan Hospital of Traditional Chinese Medicine, Kunming, China.

*Correspondence: Hongmei Shen, Integrated Traditional Chinese and Western Medicine Department, Yunnan Cancer Hospital/the Third Affiliated Hospital of Kunming Medical University, No. 519, Kunzhou Road, Xishan District, Kunming 650032, China (e-mail: lilyydz@126.com).

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2.2. Data processing

All articles were imported into Citespace and Vosviewer for analysis in plain text and tab-separated formats, in which Citespace was used to analyze cited authors and cited literature of articles, generated journal superposition graphs and burst detection of cited literature, and Vosviewer was used to analyze countries, cited institutions, and subject words of articles.

2.3. Data overview

There are 716 articles about RE in English, of which the first study was published in 1950, while less than 10 articles were published every year before 1985. Since 1991, the number of articles had remained above double digits, and the number of articles has shown a steady growth trend from 1985 to 2020. In terms of literature language, a total of 716 articles published in 7 languages were retrieved by the WOS. Of the 716 articles, 673 (93.994%) were published in English, 21 (2.933%) in French, 13 (1.816%) in Spanish, 6 (0.838%) in German, and 1 each in Chinese, Czech, and Serbian (0.14%).

3. Results

3.1. The countries and institutions

A total of 45 countries have contributed to RE research. With the threshold set to 2, Vosviewer was used to create a graph of country publishing articles with a frequency >2. Figure 1 shows 24 nodes, 86 connections, 8 clusters, and active cooperation among the countries represented by clusters corresponding to different colors. The top 6 countries are the United States (219, 30.587%), China (90, 12.57%), France (73, 10.196%), the United Kingdom (51, 7.123%), Spain (39, 5.447%), Italy (32, 4.469%), and Turkey (32, 4.469%). Other countries or regions

published 232 articles, accounting for about 32.4% of the total literature.

A total of 716 articles came from 906 institutions. The top 10 institutions published 99 articles, accounting for 13.83% of all articles published by institutions. Among the top 7 institutions, Gustav Roussi Institute (France) and Mayo Medical Center (United States) had the largest number of articles (13, 1.816%). The second-highest are Sloan Kettering Cancer Institute (United States), Nanjing University (China), Royal Adelaide Hospital (Australia), and University of Minnesota (United States). The number of articles published by these institutions is 11, each accounting for 1.536%. The University of Washington (United States) published 9 articles, accounting for 1.257%.

In the network diagram of the cited institutions, there are 161 nodes and 989 connections (Fig. 2). The 161 institutions in the diagram form a total of 12 clusters, of which cluster 1 has the most institutions, with 26 institutions (14.69%), followed by cluster 2 (20, 11.30%), cluster 3 (19, 10.73%), cluster 4 (16, 9.04%), and other 12 clusters. Among the cited institutions, active cooperation has been carried out, especially among those in the same cluster.

3.2. The author and cited author

For international research, there are 3319 authors retrieved from 716 articles. Table 1 shows the top 7 authors (4 authors tied for 7th place, a total of 10) and the cited authors. The top 7 authors contributed 92 (12.85%) articles. Delaney and Francois had the largest number of articles, with the same number of 11 (1.536%), followed by Milliat and Vozenin-Brotons, with the same number of 10 (1.397%).

Co-cited author means that the authors' articles are cited by different authors at the same time. The ranking of authors and cited authors, and the map of cited authors are shown in Table 1 and Figure 3 respectively. Among the top 10 cited authors,

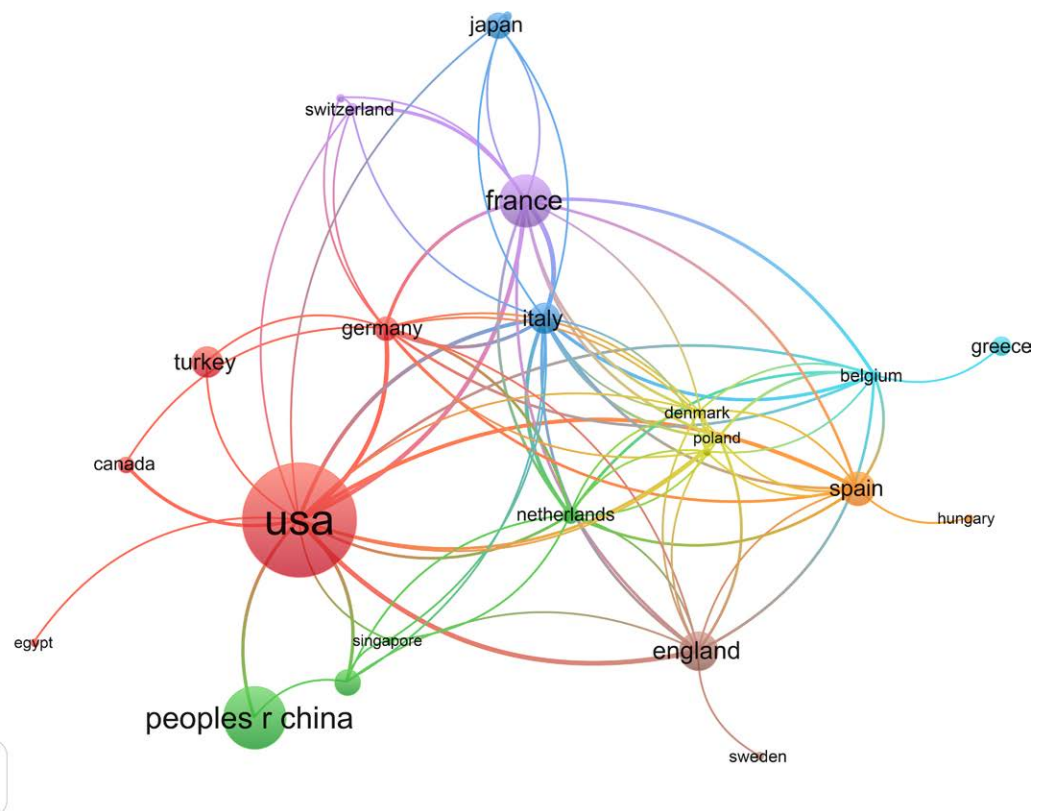


Figure 1. Network diagram of countries/regions publishing articles.

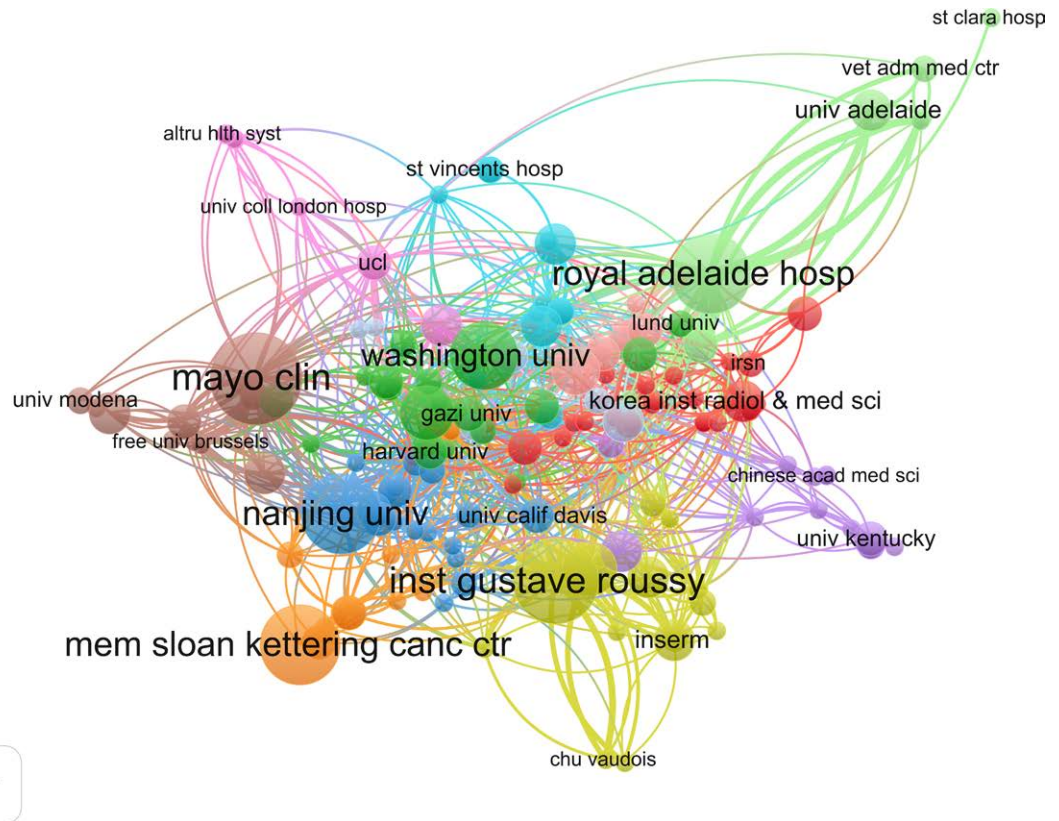


Figure 2. Network diagram of cited institutions.

Table 1
Ranking of international authors and cited authors.

Rank	Author	Article (%)	Cited author	Cited time (%)
1	Delaney	11 (1.536%)	Galland	87 (2.53%)
2	Francois	11 (1.536%)	Yeoh	55 (1.60%)
3	Milliat	10 (1.397%)	Kinsella	49 (1.43%)
4	Vozenin-Brotons	10 (1.536%)	Decosse	46 (1.43%)
5	Bourhis	9 (1.257%)	Andreyev	43 (1.25%)
6	Li	9 (1.257%)	Hauer-Jensen	39 (1.14%)
7	Andreyev	8 (1.117%)	Theis	34 (0.99%)
7	Erbil	8 (1.117%)	Andreyev	34 (0.99%)
7	Pironi	8 (1.117%)	Waddell	31 (0.90%)
7	Wang	8 (1.117%)	Berthrong	31 (0.90%)

Galland ranked first with 87 (2.53%) times, followed by Yeoh with 55 (1.60%), Kinsella with 49 (1.43%), Decosse with 46 (1.43%), and Andreyev with 43 (1.25%), while the rest of the authors were cited <31 times.

3.3. Journals and cited journals

A total of 716 articles were published in 312 journals in the international research. Tables 2 and 3 list the top 7 journals and cited journals in the field of RE. The top 7 journals have published 129 articles (18.02%). *International Journal of Radiation Oncology Biology Physics* (39, 5.447%) ranks first, followed by *Diseases of the Colon Rectum* (21, 2.933%), *Gastroenterology* (17, 2.374%), *Radiotherapy and Oncology* (15, 2.095%), and *Digestive Diseases and Sciences* (14, 1.955%). Among the top 7 journals, 6 are from the United States and 1 from the Netherlands, and the impact factors of 6 journals are <6.000.

Co-cited journals refer to journals that are cited by other scholars. Among the cited journals, *International Journal of Radiation Oncology Biology Physics* (334, 4.94%), *Gastroenterology* (200, 2.96%), *Diseases of the Colon Rectum* (182, 2.69%), *Cancer* (182, 2.69%), and *Lancet* (175, 2.59%) are the top 5. The top 7 journals are cited more than or equal to 170 times; 71.43% of the top 7 journals are from the United States, and 42.86% of the journals have an impact factor higher than 6.000.

Journal dual-map overlay is shown in Figure 4. The left side of the figure represents the field of the citing journals, and the right side represents the knowledge fields cited in the journals. The label represents the topics covered by the journals. The color curve represents the reference path, where each curve originates from the citation field and points to the cited journal field,^{19,12-171} and there are 3 main citation paths in the journal dual-map overlay.

Citing journals (left) mainly belongs to the fields of molecular biology, immunobiology, dermatology, surgery and medicine,

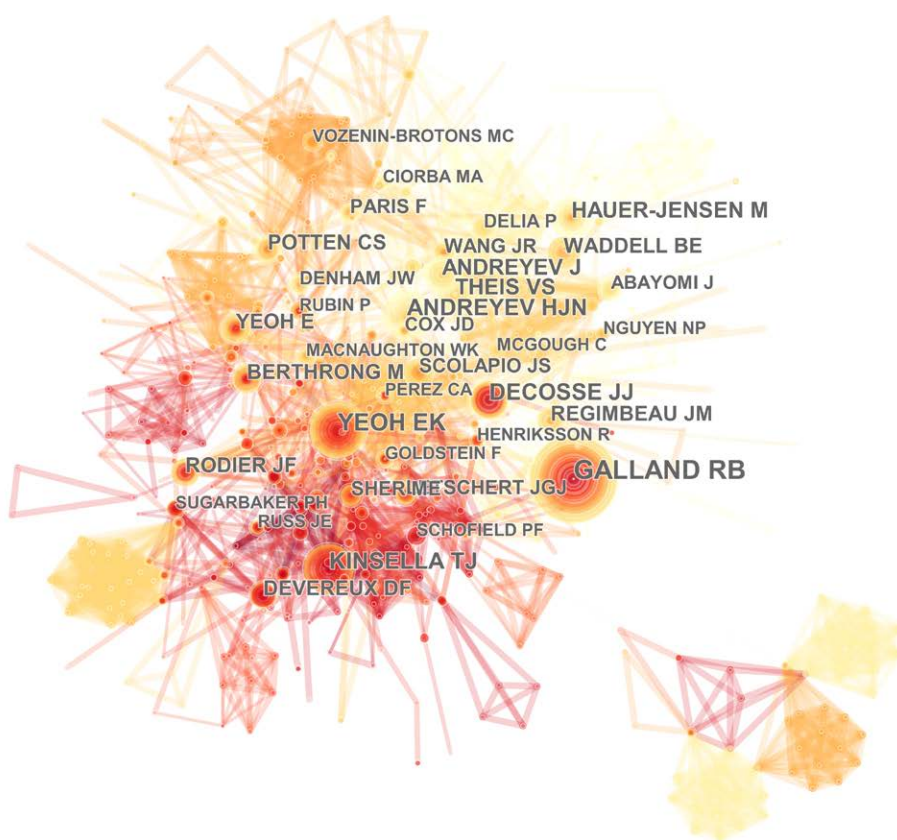


Figure 3. Network diagram of internationally cited authors.

Table 2
Ranking of recognized journals by number of papers published.

Rank	Journal	Article (%)	Country	IF
1	<i>International Journal of Radiation Oncology Biology Physics</i>	39 (5.447%)	United States	5.859
2	<i>Diseases of the Colon Rectum</i>	21 (2.933%)	United States	3.991
3	<i>Gastroenterology</i>	17 (2.374%)	United States	3.968
4	<i>Radiotherapy and Oncology</i>	15 (2.095%)	NLD	4.856
5	<i>Digestive Diseases and Sciences</i>	14 (1.955%)	United States	2.751
6	<i>Cancer</i>	12 (1.676%)	United States	5.742
7	<i>Clinical Nutrition</i>	11 (1.536%)	UK	6.36

IF = impact factor.

Table 3
Ranking of recognized cited-journals.

Rank	Cited Journal	Cites (%)	Country	IF
1	<i>International Journal of Radiation Oncology Biology Physics</i>	334 (4.94%)	United States	5.859
2	<i>Gastroenterology</i>	200 (2.96%)	United States	3.968
3	<i>Diseases of the Colon Rectum</i>	182 (2.69%)	United States	3.991
4	<i>Cancer</i>	182 (2.69%)	United States	5.742
5	<i>Lancet</i>	175 (2.59%)	UK	60.391
6	<i>Gut</i>	171 (2.53%)	UK	19.819
7	<i>Annals of Surgery</i>	170 (2.51%)	United States	10.13

IF = impact factor.

and clinical. The knowledge fields cited in the journals (right) mainly focus on environment, toxicology, nutrition, molecular biology, genetics, health, nursing, medicine, dermatology, surgery and sports, rehabilitation, and sports. Since the cited journals provided the knowledge base of the citing journals, the

trajectory of these changes shows that the research hotspots of the journals has shifted from the fields of environment, toxicology, nutrition, genetics, nursing, sports, rehabilitation and sports to molecular biology, immunobiology, dermatology, and surgery.

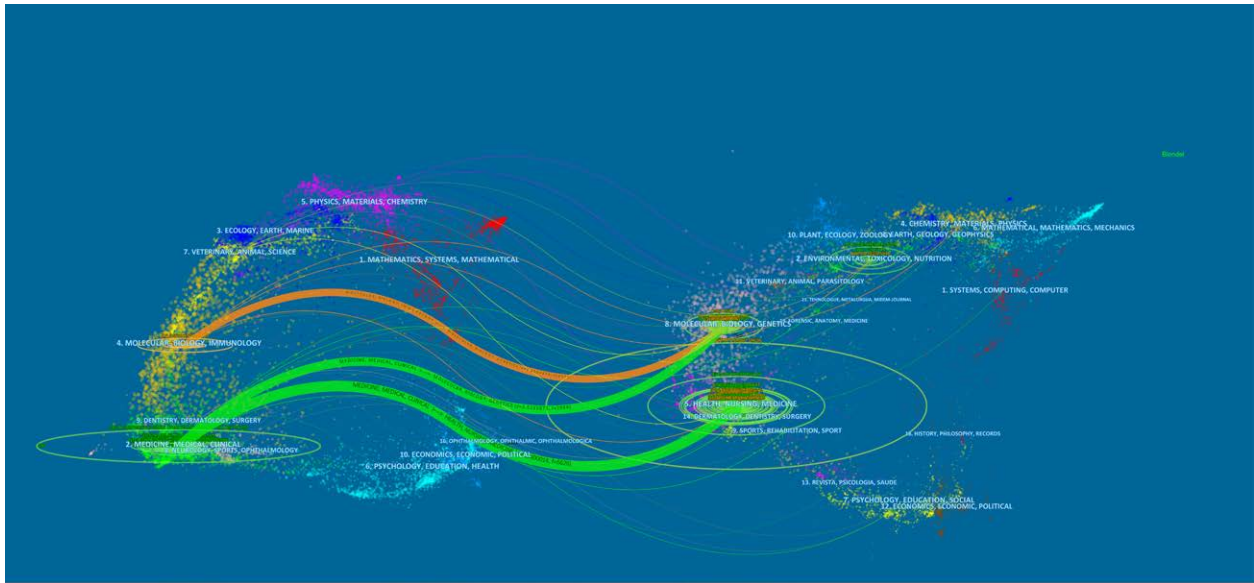


Figure 4. Overlay analysis of journals.

Table 4
Ranking of cited articles.

Title	Author	Journal	Cited time
Leukocyte-endothelial cell interactions: Molecular mechanisms and implications in gastrointestinal disease	Panes et al	<i>Gastroenterology</i>	291
Intraoperative radiotherapy in retroperitoneal sarcomas—final results of a prospective, randomized, clinical-trial	Sindela et al	<i>Archives of Surgery</i>	253
ESPEN guidelines on chronic intestinal failure in adults	Pironi et al	<i>Clinical Nutrition</i>	249
Phase 2 multi-institutional trial evaluating gemcitabine and stereotactic body radiotherapy for patients with locally advanced unresectable pancreatic adenocarcinoma	Herman et al	<i>Cancer</i>	192
Gut microbiota and inflammation	Hakansson et al	<i>Nutrition</i>	182
Healing and fibrosis in intestinal disease	Rieder et al	<i>Gut</i>	181
The dose-volume relationship of acute small bowel toxicity from concurrent 5-FU-based chemotherapy and radiation therapy for rectal cancer	Baglan et al	<i>International Journal of Radiation Oncology Biology Physics</i>	175
Home parenteral nutrition in adults: a European multicentre survey in 1997	Van Gossum et al	<i>Clinical Nutrition</i>	174
4 years of north-American registry home parenteral-nutrition outcome data and their implications for patient-management	Howard et al	<i>Journal of Parenteral and Enteral Nutrition</i>	169
Survival of home parenteral nutrition-treated patients: 20 years of experience at the Mayo Clinic	Scolapio et al	<i>Mayo Clinic Proceedings</i>	157

3.4. Cited literature

For international research, Table 4 lists the top 10 citations related to the study of RE. The top 10 references are cited more than 202 times on average, among which 4 cited literature were cited more than 200 times. A literature with a cited burst is defined as being frequently referenced over a period of time. When analyzing references through Citespace, we set the threshold to the top 50, took every year as a time slice, selected cutting mode as pathfinder + pruning sliced networks + pruning the merged network, and finally got Figure 5, and 21 citations with strong bursts were detected (Fig. 6). In Figure 6, the blue line represents the time interval, the red line represents the time period of the outbreak. The emergence of the citation first appeared in 1991, while the literature with the highest emergence intensity began in 2011 and ended in 2018, and the latest emergence references appeared in 2014.

3.5. Keywords and clustering

A total of 13,350 keywords were extracted from 716 articles from international research. There were 336 keywords with a

frequency of more than 10 times, the first 202 were selected to generate a density visualization map with Vosviewer (Fig. 7).

As shown in Table 5, effect is the most important keyword, with a total of 193 times, followed by complication (151), irradiation (151), surgery (124), injury (122), case (118), and level (103). Among the top 20 keywords, some are related to the etiology and pathological mechanisms of RE, such as irradiation, injury, tissue, cancer, and chemotherapy. Others are mostly related to treatment, such as surgery and resection. Some are related to experimental modeling, such as Eat and Model.

Co-occurrence keywords was clustered and analyzed. Vosviewer was used to create a visual map of keywords (Fig. 8). The software extracted the keywords from the titles and abstracts of 716 articles, calculated the cumulative frequency of the keywords, and set the threshold to 40.00%, because the keywords with a high frequency can accurately display the topic of a field. After calculation, the keyword network diagram was generated. There are 202 nodes and 10,957 connections in the network diagram, and these high-frequency keywords form 2 clusters (Fig. 8). Category 1 has the largest number of keywords, with a total of 110 keywords, which are mainly related to the etiology and complications of RE, such as carcinoma, cervical

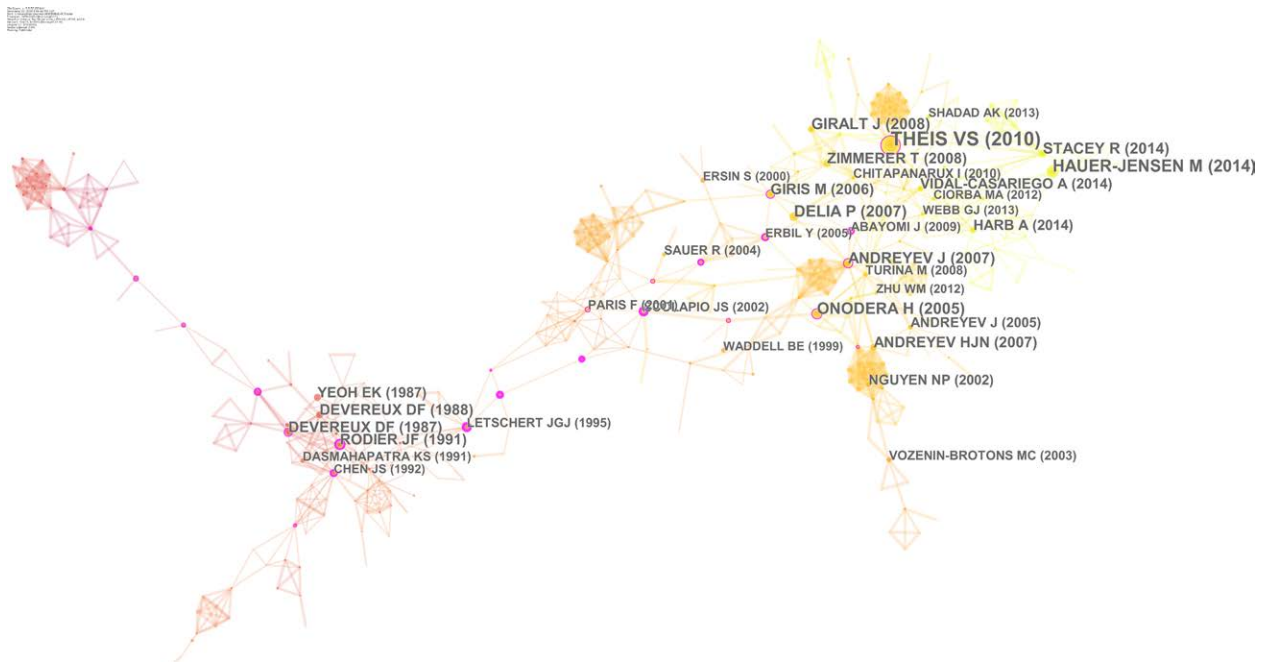


Figure 5. Network diagram of co-cited papers.

Cited literature	Strength	Begin	End	1950-2020
DEVEREUX DF, 1988, DIS COLON RECTUM, V31, P17,	5.9549	1991	1996	
DEVEREUX DF, 1987, SURGERY, V101, P123	6.1682	1991	1995	
YEOH EK, 1987, SURG GYNECOL OBSTET, V165, P373	5.8226	1992	1995	
RODIER JF, 1991, CANCER, V68, P2545, DOI	6.0947	1994	1999	
DASMAHAPATRA KS, 1991, ARCH SURG-CHICAGO, V126, P366	4.4198	1994	1999	
LETSCHERT JGJ, 1995, EUR J CANCER, V31A, P1361	4.4892	1997	2003	
VOZENIN-BROTONS MC, 2003, INT J RADIAT ONCOL, V56, P561	4.5105	2004	2007	
WADDELL BE, 1999, J AM COLL SURGEONS, V189, P611	4.3998	2005	2006	
NGUYEN NP, 2002, CANCER, V95, P1151	4.5807	2006	2010	
ONODERA H, 2005, WORLD J SURG, V29, P459	5.3412	2007	2011	
ANDREYEV J, 2007, LANCET ONCOL, V8, P1007	5.7097	2009	2013	
GIRALT J, 2008, INT J RADIAT ONCOL, V71, P1213	4.6558	2010	2016	
ANDREYEV HJN, 2007, CLIN ONCOL-UK, V19, P790	4.9472	2010	2014	
DELIA P, 2007, WORLD J GASTROENTERO, V13, P912	5.873	2010	2015	
GIRIS M, 2006, AM J SURG, V191, P503	4.9472	2010	2014	
THEIS VS, 2010, CLIN ONCOL-UK, V22, P70	11.2144	2011	2018	
ZIMMERER T, 2008, Z GASTROENTEROL, V46, P441	4.9443	2011	2016	
VIDAL-CASARIEGO A, 2014, JPEN-PARENTER ENTER, V38, P205	5.542	2015	2020	
HAUER-JENSEN M, 2014, NAT REV GASTRO HEPAT, V11, P470	8.0438	2015	2020	
HARB A, 2014, CURR GASTROENTEROL REP, V16, P383	5.0143	2016	2020	
STACEY R, 2014, THER ADV CHRONIC DIS, V5, P15	7.3298	2017	2020	

Figure 6. Analysis of the emergence of cited articles.

cancer, chemoradiotherapy, bowel obstruction, fistula, cystitis, etc. Category 2 has 92 keywords, which are mainly related to the influence, clinical trials and animal experiments of RE, such as injury, irradiated mice, animal model, control group, double blind, and so on.

4. Discussion

We used the core collection in the WOS as the data source, including 716 articles. A total of 45 countries have participated in the publication of 716 articles in this field, of which the United States ranks first, followed by China, France, Britain, and Spain. Although the number of articles published in China is second only to the United States, the number of articles published in the United States is about 2.5 times that of China, reflecting the

large gap in the frequency and depth of research between China and the United States. A total of 906 international institutions have participated in the publication of the articles in this field. The top 5 institutions are the Gustav Lucii Institute in France, the Mayo Medical Center and the Sloan Kettering Cancer Institute in the United States, Nanjing University in China, and Royal Adelaide Hospital in Australia. Nanjing University in China has a certain influence in the international research of RE, but it lacks cooperation with international institutions.

A total of 129 articles were published in the top 7 international journals in the field of RE, accounting for 18.02% of all literature. Among the top 7 journals, 6 were from the United States and 1 was from the Netherlands. Among the 7 journals, the highest impact factor was 6.36, the lowest was 2.751, and the average was 4.7896. Among all cited journals, the top 7

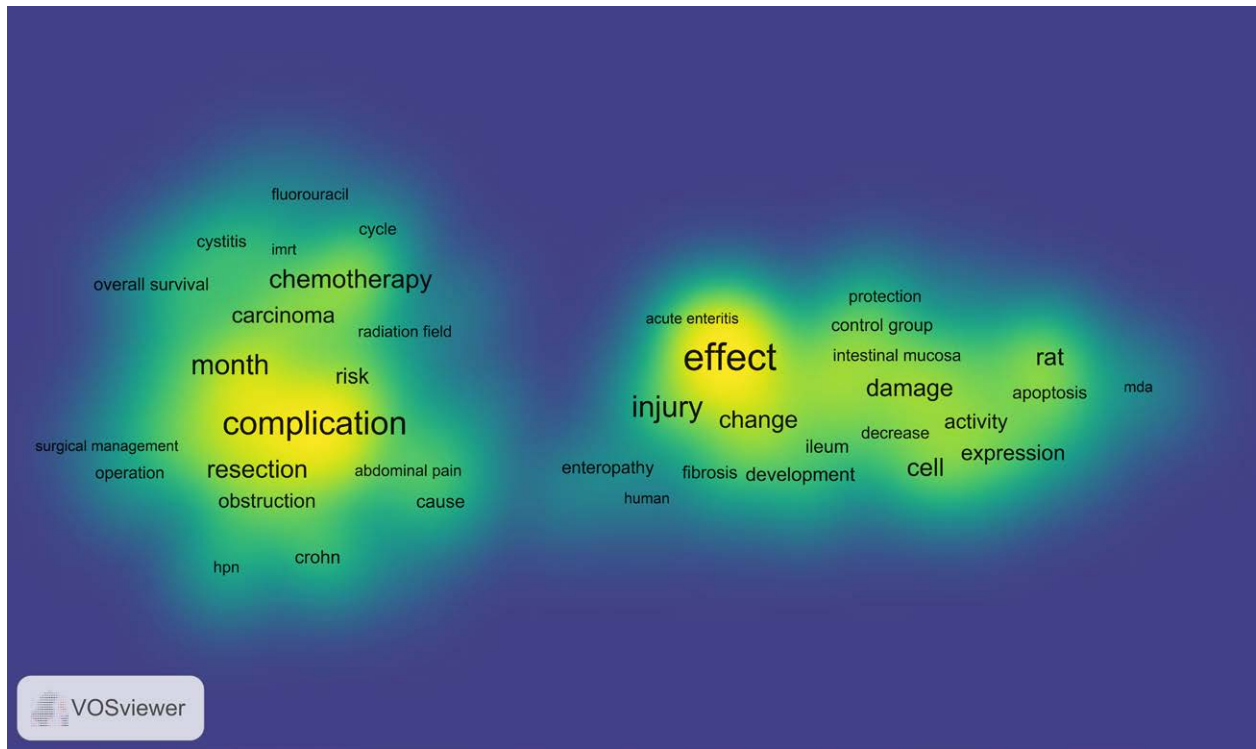


Figure 7. Visualization map of density.

Table 5
Keywords with high frequency.

Rank	Keywords	Frequency	Rank	Keywords	Frequency
1	Effect	193	11	Grade	80
2	Complication	151	12	Rat	75
3	Irradiation	151	13	Damage	74
4	Surgery	124	14	Change	72
5	Injury	122	15	Management	70
6	Case	118	16	Tissue	64
7	Level	103	17	Carcinoma	63
8	Chemotherapy	87	18	Model	63
9	Cell	82	19	Outcome	63
10	Resection	82	20	Morbidity	62

journals have the highest impact factor of 60.391 and the lowest of 3.991, with an average of 15.7. Among the top 7 cited journals, 5 journals (71.43%) are from the United States, followed by the Netherlands and the United Kingdom, each with 1 journal.

A total of 3319 authors participated in the publication of international literature, and the top 7 authors contributed 92 (12.85%) articles. In terms of the number of articles, the key authors are Delaney, Francois, Milliat, and Vozenin-Brotons. In terms of cited frequency, the key authors are Galland, Yeo, Kinsella, Decosse, and Andreyev.

Among the cited international literature, the most cited literature is the review published in 1998 by Panes et al. This review discusses that related adhesion molecules from different families participated in the coordinated recruitment of leukocytes into inflammatory tissues, and the pathophysiological change was observed in experimental models of gastrointestinal diseases, including ischemia or reperfusion injury, RE, inflammatory bowel disease, and inflammatory response to substances released by *Helicobacter pylori* and *Clostridium difficile*.^[18] The second most cited literature is a prospective

randomized clinical trial of intraoperative radiotherapy for retroperitoneal sarcoma published in *Archives of Surgery* by Sindela et al.^[19] The third is the adult chronic intestinal failure guide from European Society of Parenteral and Enteral Nutrition (ESPEN) published by Pironi et al in *Clinical Nutrition*.^[20]

In terms of subject words, 13,350 subject words have been used in the field of RE, of which only 68 have a frequency greater than or equal to 30, indicating that the utilization rate of most subject words is not high. The main high-frequency subject words are radiation (416, 24.16%), enteritis (266, 12.54%), intestinal (105, 6.10%), induced (104, 6.03%), patients (91, 5.28%), cancer (82, 4.76%), and radiotherapy (80, 4.65%). The high-frequency subject words formed 2 clusters, and the first category had the largest number of subject words, with a total of 110 subject words, which were mainly related to the etiology and complications of RE. The second category had 92 subject words, which were mainly related to the influence of RE, clinical trials, and animal experiments. According to the burst detection of keywords (Fig. 9), it is predicted that clinical double-blind trial of RE, the related mechanisms such as oxidative stress and

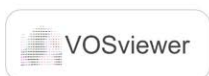
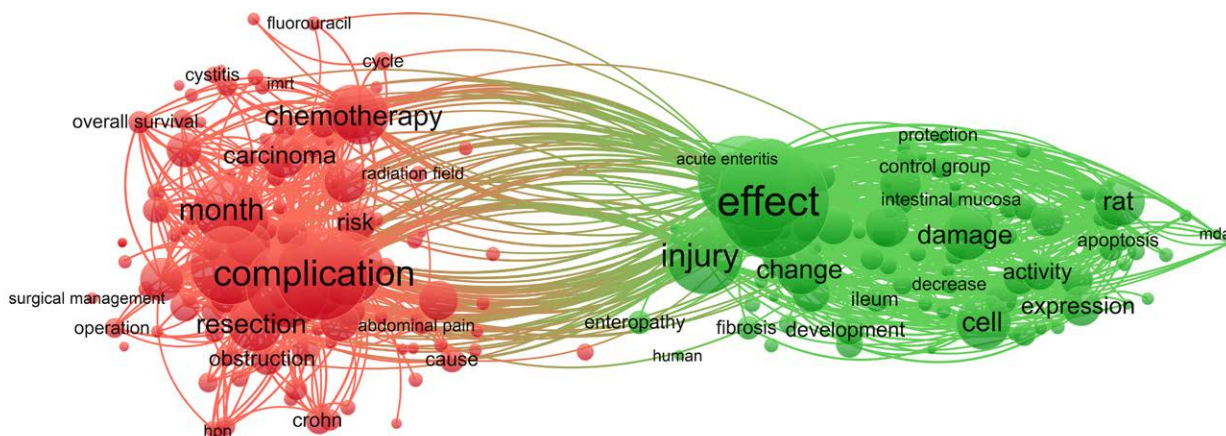


Figure 8. Visualization map of keywords.

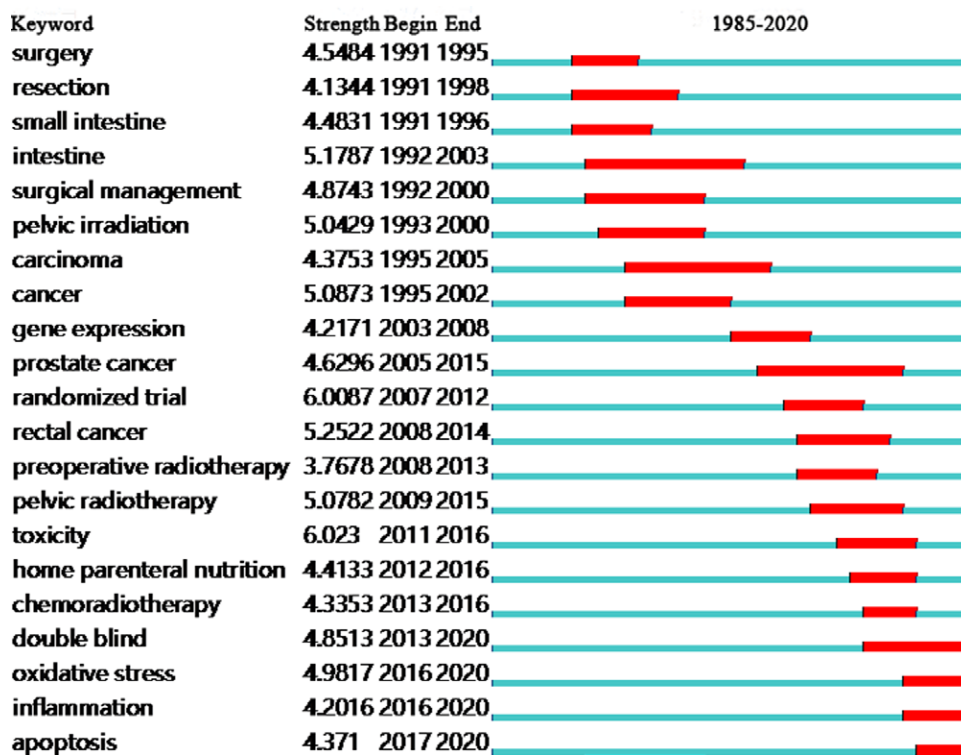


Figure 9. Analysis on the emergence of keywords.

apoptosis will become the future research hotspot in the field of international RE.

5. Conclusion

Considering that the scientific metrological analysis of RE has not been found yet, this study aims to provide researchers with an overview of research in this field, in order to show its development status and research hotspots. On the basis of the summary of this paper, statistical analysis methods will be used to further compare the results and data differences of relevant

literature in the future, in order to obtain more comprehensive and complete analysis results.

Author contributions

Conceptualization: Yingjia Zhou, Daman Chen.
Data curation: Daman Chen, Weibo Wen, Hongmei Shen, Mingxin Dong.
Methodology: Yingjia Zhou, Kaibo Zhao, Yongqi Guo, Jiaxi Cai.
Project administration: Yingjia Zhou, Daman Chen.

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