

Global trends in *Helicobacter pylori* research from 1991 to 2008 analyzed with the Science Citation Index Expanded

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Objective In this study, we aim to evaluate the global scientific production of *Helicobacter Pylori* (*H. pylori*) research, study the characteristics of *H. pylori* research activities, and identify patterns, tendencies, and regularities of *H. pylori*-related articles.

Methods Data were based on the online version of Science Citation Index Expanded, from the Web of Science database. Articles referring to *H. pylori* were assessed by the trend of publication output during 1991–2008, and analysis of the distribution of words in the article title, author keyword, and KeyWords Plus was carried out.

Results Globally, 37451 papers were published during the 18-year study period, including 19 080 articles, 10 396 meeting abstracts, 2625 reviews, 1943 proceedings papers, and 1866 letters. There were totally 1727 journals listed in the 122 Science Citation Index subject categories. The mainstream research on *H. pylori* was in the clinical gastroenterology and hepatology, microbiology, and pharmacology and pharmacy fields. The G7 industrial countries held the majority of total world production. Research on the *H. pylori*-related topic ‘ulcer’ remained the hotspot of *H. pylori* research, whereas that on the related

topic ‘gastric cancer’ increased during the 18-year study period.

Conclusion With synthetic analysis of word in article title, author keyword, and KeyWords Plus, it can be concluded that application of *H. pylori* in clinical gastroenterology, especially research related to ‘cancer’ is the orientation of all the *H. pylori* research in the 21st Century. This bibliometric method can help relevant researchers understand the panorama of global *H. pylori* research, and establish the direction of further research. *Eur J Gastroenterol Hepatol* 23:295–301 © 2011 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Introduction

Since the isolation of *Helicobacter pylori* (*H. pylori*) from gastric biopsies in 1983 by Warren and Marshall [1,2] in Perth, Australia, a new era of understanding of gastroduodenal disorders has opened. *H. pylori* infection is almost always associated with inflammation of the gastric mucosa and peptic ulcer disease. However, gastric carcinoma and mucosa-associated lymphoid tissue lymphoma occur in a subset of individuals chronically infected with *H. pylori* [3]. The organism was previously included in the *Campylobacter* genus and the name *Helicobacter* was reported in October 1989 [4].

Despite the importance of *H. pylori* infection in gastroduodenal disease, there have been few attempts to gather systematic data on the global scientific production of *H. pylori* research. A common research tool for this analysis is the bibliometric methods, which have already been widely applied for scientific production and research trends in many disciplines of science and engineering [5–7]. Furthermore, the Science Citation Index Expanded (SCI Expanded), from the Institute for Scientific Information (ISI), Web of Science database is the

most important and frequently used source database for a broad review of scientific accomplishment in all fields of study [8,9]. Conventional bibliometric methods often evaluate research trends by the publication output of countries, research institutions, journals, and research fields [10–12] or by citation analysis [13–15]. However, merely depending on changes in citations or publication counts from countries and organizations cannot completely indicate the development of trends or future orientation of a research field. More information, closer to the research itself, such as article titles, author keywords, KeyWords Plus, and abstracts, should be introduced in the study of research trends. KeyWords Plus in the SCI Expanded database supplies additional search terms extracted from the titles of articles cited by authors in their bibliographies and footnotes [16]. In recent years, words in article titles, author keywords, KeyWords Plus, and abstracts have been separated into different time periods to analyze variations in research trends [7,17,18]. Furthermore, a method called ‘word-cluster analysis’ has been successfully applied to find research hotspots in the risk assessment field [19].

In this study, we aim to synthetically use the traditional method, with study field and country analysis, and the innovative method, with article title, author keyword, and KeyWords Plus analysis, to map trends in global *H. pylori* research from 1991 to 2008, to help researchers understand the panorama of global *H. pylori* research, and establish the direction of further research.

Methods

These data were based on the online version of the SCI Expanded, Web of Science. SCI Expanded is the multi-disciplinary database of the ISI, Philadelphia, Pennsylvania, USA. According to the Journal Citation Reports (JCR), it indexed 6620 major journals with citation references across 173 scientific disciplines in 2008. The online version of SCI Expanded was searched under the keywords '*Helicobacter Pylori*', '*H. pylori*', '*campylobacter pylori*', and '*C. pylori*' to compile a bibliography of all papers related to *H. pylori* research. Articles originating from England, Scotland, Northern Ireland, and Wales were reclassified as being from the UK. In addition, the reported impact factor of each journal was obtained from the 2008 JCR. Contributions of different institutions and countries were estimated by affiliation with at least one researcher of the publications. Collaboration type was determined by the researchers' addresses, where the term 'single-country article' was assigned if the researchers' addresses were all from the same country. The term 'internationally collaborative article' was designated for those articles coauthored by researchers from multiple countries. The term 'single-institution article' was assigned if the researchers' addresses were all from the same institution. The term 'interinstitutionally collaborative article' was assigned if researchers were from different institutions. The document type, language of publication, characteristics of publication output, subject categories, journals as well as distribution of words in the article title, author keywords, and KeyWords Plus were assessed in all articles from 1991 to 2008 referring to *H. pylori*.

Results

Document type and language of publication

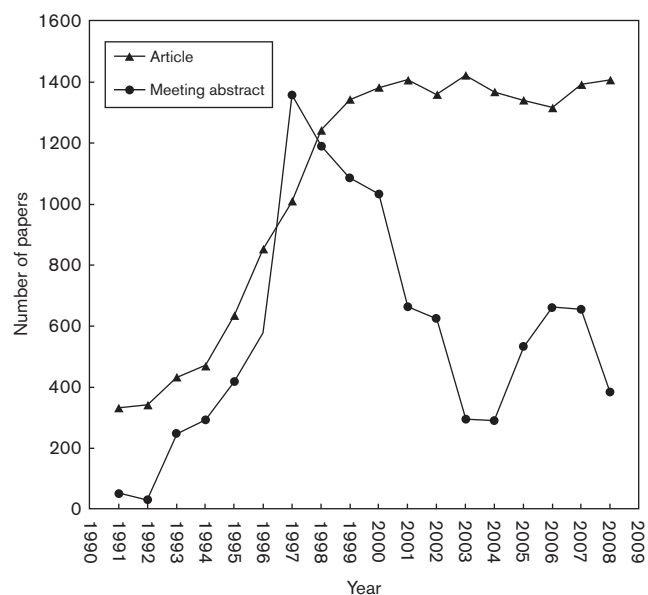
The distribution of the document type identified by ISI was analyzed. From this study, 13 document types were found in the total 37 451 publications during the 18-year study period. An article (19 080) was the most frequently used document type comprising 51% of the total production, followed by meeting abstracts (10 396; 28%), reviews (2625; 7.0%), proceedings papers (1943; 5.2%), letters (1866; 5.0%), and editorial materials (1068; 2.9%). The others showing less significance were notes (228), corrections (119), new items (77), addition corrections (22), discussions (12), reprints (12), and biographical-items (3). Three hundred and thirty-two articles were published in 1991. The number of articles increased progressively to a plateau of 1244 articles in 1998 and

maintained a steady rate over the following years (Fig. 1). The number of meeting abstracts increased after 1991 and reached a peak of 1358 in 1997, then rapidly decreased to a nadir of 289 in 2004. However, there has been a slow increase in the number of meeting abstracts since 2004. Journal articles represent the majority of document types. Only 19 080 articles were used for further analysis. Ninety-six percent of all of these journal articles were published in English. Several other languages also appeared, containing German (263; 1.4%), French (201; 1.1%), Spanish (142; 0.74%), and Russian (80; 0.42%). Languages, which were generally less used included Chinese (16), Japanese (13), Polish (11), Portuguese (4), Korean (3), Turkish (2), Hungarian (2), and one for each in Arabic, Rumanian, Lithuanian, Italian, Dutch, and Serbian.

Publication distribution by country

The contribution of different countries was estimated by the location of the affiliation of at least one author of the published articles. There were 84 articles without any researcher address information on the ISI, Web of Science. Of the 18 996 articles with researcher addresses, 15 612 (82%) were single-country articles and 3384 (18%) were internationally collaborative articles. The top 20 countries were ranked by number of articles, including the number and percent of single country articles, internationally collaborative articles, first author articles, and corresponding author articles (Table 1). Two North American countries, 11 European countries, six Asian

Fig. 1



Trends of articles and meeting abstracts on *Helicobacter pylori* from 1991 to 2008.

Table 1 Top 20 most productive countries of articles during 1991–2008

Country	Total number of articles (%)	Number of independent articles	Rank (%)	Number of internationally collaborative articles	Rank (%)	Number of first author articles	Rank (%)	Number of corresponding author articles	Rank (%)	%C
USA	4376 (23)	2804	1 (18)	1572	1 (46)	3519	1 (19)	3223	1 (19)	36
Japan	2707 (14)	2269	2 (15)	438	4 (13)	2508	2 (13)	2416	2 (14)	16
UK	1883 (9.9)	1224	4 (7.8)	659	2 (19)	1476	3 (7.8)	1248	5 (7.2)	35
Germany	1754 (9.2)	1135	5 (7.3)	619	3 (18)	1406	5 (7.4)	1299	3 (7.5)	35
Italy	1671 (8.8)	1240	3 (7.9)	431	5 (13)	1449	4 (7.6)	1281	4 (7.4)	26
France	850 (4.5)	512	6 (3.3)	338	7 (10)	647	6 (3.4)	593	6 (3.4)	40
Sweden	805 (4.2)	387	12 (2.5)	418	6 (12)	575	7 (3.0)	506	7 (2.9)	52
Canada	717 (3.8)	413	11 (2.6)	304	8 (9.0)	559	8 (2.9)	482	9 (2.8)	42
Netherlands	665 (3.5)	420	10 (2.7)	245	9 (7.2)	520	9 (2.7)	494	8 (2.8)	37
South Korea	554 (2.9)	457	7 (2.9)	97	19 (2.9)	490	10 (2.6)	469	10 (2.7)	18
Australia	547 (2.9)	311	14 (2.0)	236	10 (7.0)	411	13 (2.2)	374	13 (2.2)	43
Spain	535 (2.8)	421	9 (2.7)	114	17 (3.4)	458	11 (2.4)	406	11 (2.3)	21
China	532 (2.8)	308	15 (2.0)	224	11 (6.6)	386	14 (2.0)	360	14 (2.1)	42
Taiwan	466 (2.5)	422	8 (2.7)	44	30 (1.3)	442	12 (2.3)	403	12 (2.3)	9
Turkey	363 (1.9)	330	13 (2.1)	33	35 (1.0)	347	15 (1.8)	337	15 (1.9)	9
Finland	360 (1.9)	243	16 (1.6)	117	16 (3.5)	285	16 (1.5)	249	16 (1.4)	33
Switzerland	302 (1.6)	117	26 (0.75)	185	12 (5.5)	191	22 (1.0)	188	20 (1.1)	61
Ireland	289 (1.5)	143	21 (0.92)	146	13 (4.3)	197	21 (1.0)	158	22 (0.91)	51
Poland	284 (1.5)	146	20 (0.94)	138	14 (4.1)	219	19 (1.2)	202	19 (1.2)	49
Hong Kong	280 (1.5)	174	19 (1.1)	106	18 (3.1)	235	17 (1.2)	222	17 (1.3)	38

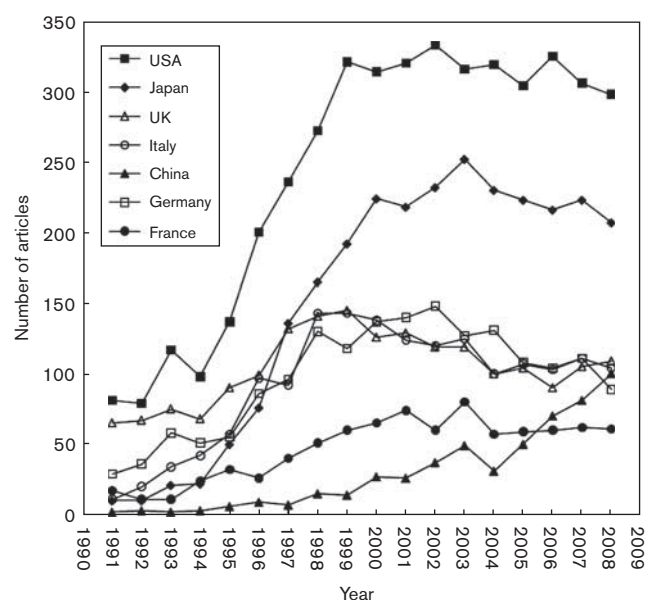
%C, the percent of internationally collaborative articles in total articles for each country.

countries, and Australia were ranked in the top 20. Six of the seven major industrialized nations of the world (G7), the USA, Japan, the UK, Germany, Italy, and France were the top six countries of publication. Canada ranked the ninth. The United States most frequently collaborated with international partners, accounting for 46% of all internationally collaborative articles in the world. Compared with its total publications, the USA had a high percent (36%) of collaboration with outside researchers.

An obvious increase can be seen in the number of articles related to *H. pylori* research in all six countries, whereas the rapid development of global *H. pylori* research was partly driven by contributions of these countries (Fig. 2). Japan had the highest growth pace, with a lower share (16%) of internationally collaborative articles in its total articles among the top 20 productive countries. In addition, China ranked 13 but it was the only country with an increasing number of articles in recent years. Since the Chinese Society of Gastroenterology held the Chinese National Chronic Gastritis Meeting in 2000, advances have been made in the study of *H. pylori* infection in China [20].

Publication distribution by institution

The contributions of different institutions were estimated by the affiliation of at least one author. Of the 18996 articles with researcher address information in the ISI database, 7643 (40%) were independent articles and 11353 (60%) were collaborations by two or more institutions. Table 2 shows that among the top 20 institutions, six (30%) were in the USA. Leading institutions were Baylor College of Medicine, Veterans Affairs Medical Center, and Vanderbilt University in the USA, which published more than 300 *H. pylori*-related articles from 1991 to 2008. The University of Hong Kong

Fig. 2

Publication trends of the top six countries and China.

had the lowest percent of interinstitutional collaborative articles in total articles for each institute (%C), whereas Baylor College of Medicine had the highest value with 98%. Veterans Affairs Medical Center had the highest number of first and corresponding author articles.

Distribution of output by journal and subject category

In total, 19080 articles in 122 SCI subject categories were published in 1727 journals. There were six journals with more than 500 published articles, which refer to *H. pylori*

Table 2 Top 20 most productive institutes of articles during 1991–2008

Institution	Total number of articles	Total number of article rank (%)	Independent articles rank (%)	Interinstitutionally collaborative article rank (%)	First author article rank (%)	Corresponding author article rank (%)	%C
Baylor College of Medicine, USA	398	1 (2.1)	208 (0.1)	1 (3.4)	27 (0.36)	72 (0.20)	98
Veterans Affairs Medical Center, USA	360	2 (1.9)	135 (0.14)	2 (3.1)	1 (1.0)	1 (1.0)	97
Vanderbilt University, USA	309	3 (1.6)	89 (0.20)	3 (2.6)	2 (0.81)	2 (0.76)	95
University of Helsinki, Finland	185	4 (1.0)	10 (0.55)	6 (1.3)	4 (0.59)	6 (0.51)	77
University of Texas, USA	185	4 (1.0)	4 (0.65)	10 (1.2)	7 (0.54)	5 (0.54)	73
University of Bologna, Italy	176	6 (0.93)	13 (0.51)	9 (1.2)	6 (0.56)	14 (0.4)	78
University of Padua, Italy	166	7 (0.87)	107 (0.18)	4 (1.3)	12 (0.43)	25 (0.32)	92
Karolinska Institute, Sweden	160	8 (0.84)	53 (0.26)	8 (1.2)	12 (0.43)	15 (0.39)	88
University of New South Wales, Australia	159	9 (0.84)	6 (0.60)	13 (1.0)	8 (0.48)	8 (0.46)	71
Department of Veterans Affairs Medical Center, USA	155	10 (0.82)	395 (0.052)	5 (1.3)	55 (0.25)	81 (0.19)	97
Washington University, USA	155	10 (0.82)	107 (0.18)	7 (1.2)	23 (0.37)	34 (0.29)	91
Seoul National University, South Korea	151	12 (0.79)	3 (0.71)	23 (0.85)	5 (0.58)	4 (0.60)	64
University of Hong Kong, Hong Kong	147	13 (0.77)	2 (0.82)	30 (0.74)	3 (0.62)	3 (0.64)	57
University of Tokyo, Japan	147	13 (0.77)	15 (0.48)	14 (1.0)	12 (0.43)	11 (0.43)	75
Klinikum Bayreuth, Germany	146	15 (0.77)	89 (0.20)	11 (1.2)	50 (0.26)	52 (0.24)	90
University of Munich, Germany	142	16 (0.75)	12 (0.52)	19 (0.9)	9 (0.45)	9 (0.46)	72
McMaster University, Canada	141	17 (0.74)	21 (0.46)	16 (0.93)	16 (0.41)	19 (0.37)	75
Hokkaido University, Japan	127	18 (0.67)	28 (0.38)	21 (0.86)	34 (0.31)	23 (0.33)	77
Hiroshima University, Japan	126	19 (0.66)	26 (0.39)	24 (0.85)	10 (0.45)	7 (0.48)	76
Pasteur Institute, France	124	20 (0.65)	19 (0.47)	28 (0.78)	27 (0.36)	28 (0.31)	71

%C, the percent of interinstitutionally collaborative articles in total articles for each institute.

research from 1991 to 2008. Nineteen percent of the articles were in these six journals. *Alimentary Pharmacology and Therapeutics* published the most articles (767; 4.0%), followed by *Helicobacter* with 616 articles and *American Journal of Gastroenterology* with 606 articles (Table 3). *Helicobacter* was established in 1996, and its first SCI Expanded article appeared in 1997. The number of publications of *H. pylori*-related articles increased rapidly from 1997 to 2008 in this journal, and it became the leading journal in the *H. pylori*-related research field with 59 publications in 2008.

On the basis of the classification of SCI Expanded subject categories in JCR, the publication output data of *H. pylori* research was distributed among 122 SCI Expanded subject categories. Subject categories containing over 1000 *H. pylori*-related articles are statistically analyzed in Fig. 3. There were eight major categories studied. The subject category of *Gastroenterology and Hepatology* was the most common research interest of *H. pylori* authors, followed by microbiology and pharmacology and pharmacy.

Analysis of article titles

The title of an article includes information that the author would most like to express to readers. We statistically analyzed single words in the titles of *H. pylori*-related articles. Empty words such as prepositions, articles, and conjunctions, and common words such as 'infection', 'patients', 'study', 'disease', 'effect', 'risk', and 'associated' were discarded in the analysis. Some words related to

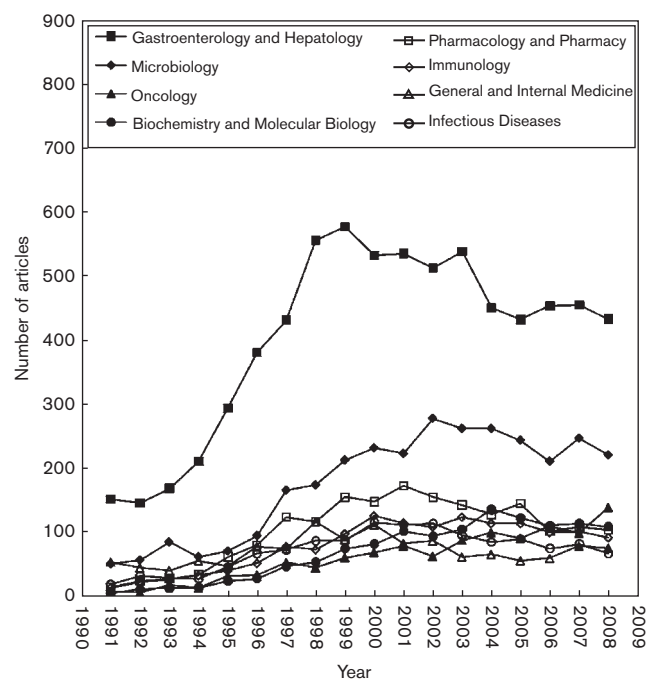
therapy for *H. pylori*, such as 'eradication', 'ulcer', and 'gastritis' were emphasized in the title. The use of the words 'cancer', 'cells', 'treatment', 'expression', and 'risk' increased. Moreover, the rank and percent of 'gene' and 'protein' increased from '58th, 1.5%' and '78th, 1.2%' in 1991–1996 to '12th, 4.0%' and '14th, 3.9%' in 2003–2008. This indicates, apparently, that *H. pylori*-related genes and proteins attracted increased attention.

Analysis of author keywords and KeyWords Plus

Author keyword analysis offers information about research trends that concern researchers. Author keywords, which appeared in articles referring to *H. pylori* were calculated and ranked for the total 18 years and for 6-year time periods. Author keywords that appeared more than 170 times in the last 18 years are shown in Table 4. A rough estimate of research changes could be found. Except for '*Helicobacter Pylori*', '*Helicobacter-pylori*', and '*H. pylori*', which were searching keywords, the three most frequently used keywords were 'gastritis', 'gastric cancer', and 'duodenal ulcer'. These three words are also the basis of all *H. pylori* research in the world. However, over the past 18 years, the keywords of 'duodenal ulcer', 'peptic ulcer', and 'gastric ulcer' decreased in ranking among author keywords. This indicates that *H. pylori*-related ulcers attracted less attention during the last 6 years of the survey. In contrast, the keyword 'gastric cancer' clearly increased over the 18-year study period. The rank and percent of articles with 'gastric cancer' were 'ninth and 3.7%' in 1991–1996, and increased to 'second and

Table 3 Top 10 journals with subject category and impact factor

Journal title	Total number of articles (%)	Impact factor	Subject category
<i>Alimentary Pharmacology and Therapeutics</i>	767 (4.0)	1.215	Gastroenterology and Hepatology, Pharmacology and Pharmacy
<i>Helicobacter</i>	616 (3.2)	2.47	Gastroenterology and Hepatology, Microbiology
<i>American Journal of Gastroenterology</i>	606 (3.2)	6.444	Gastroenterology and Hepatology
<i>Digestive Diseases and Sciences</i>	571 (3.0)	1.583	Gastroenterology and Hepatology
<i>Scandinavian Journal of Gastroenterology</i>	546 (2.9)	1.98	Gastroenterology and Hepatology
<i>Infection and Immunity</i>	546 (2.9)	3.987	Immunology Infectious Diseases
<i>Gut</i>	439 (2.3)	9.766	Gastroenterology and Hepatology
<i>European Journal of Gastroenterology and Hepatology</i>	409 (2.1)	2.08	Gastroenterology and Hepatology
<i>Journal of Gastroenterology and Hepatology</i>	374 (2.0)	2.275	Gastroenterology and Hepatology
<i>Gastroenterology</i>	326 (1.7)	12.591	Gastroenterology and Hepatology

Fig. 3Comparison of the growth trends in subject categories containing over 1000 *Helicobacter pylori*-related articles.

7.8%’ in 2003–2008. This implies that more attention was paid to research of topics related to ‘gastric cancer’ in the last decade.

KeyWords Plus provides search terms extracted from the titles of papers cited in each new article in the database in the ISI [16]. The distribution of the KeyWords Plus with ranks and percentages in different periods has shown results similar to the author keywords rankings. Some words such as ‘eradication’, ‘duodenal ulcer’, ‘gastritis’, and ‘cancer’ were also emphasized in KeyWords Plus. However, almost all words other than ‘gastritis’ had low growth rates or even increased in recent years. The rank of many other KeyWords Plus did not fluctuate clearly in the study periods, which shows that the development of *H. pylori* research was basically steady and concentrated over the past 18 years.

Discussion

This study provides interesting information with regard to global trends in *H. pylori* research from 1991 to 2008. Over the past 2 decades, marked progress in the area of the *H. pylori* research has been made. Along with the development of SCI Expanded, *H. pylori* research expanded during this time, increasing significantly in 1991 and rocketing in the 21st Century. Built on many breakthroughs from 1991 to 2008, especially in the recent decade, *H. pylori* research has become one of the most important and dynamic fields of study in gastroenterology. *H. pylori* research has been steadily developing in various categories. The three most common categories were gastroenterology and hepatology, microbiology, and pharmacology and pharmacy. As the use of statistics in any scientific discipline can be considered a key element in evaluating its degree of maturity [14], this result provides a current view of the *H. pylori* research emphases of this topic. However, even though Koch’s postulates were fulfilled by the self-infection experiment of Marshall in 1983 [1,2], the field of *H. pylori* research did not gain much attention until the 1990s. In the 1980s, the acid-pepsin theory dominated the research field in gastroenterological studies and delayed the acceptance of the *H. pylori* theory for years. Clinical research on *H. pylori* increased rapidly in the 1990s and these clinical studies provide evidence of the association of *H. pylori* infection with an increased risk of peptic ulcer disease, gastric cancer, mucosa-associated lymphoid tissue lymphoma, and possibly with some cases of dyspepsia.

Figure 1 shows the number of SCI Expanded articles referring to ‘*H. pylori*’ increased rapidly after 1994, reaching a peak in 1997, and then plateaued showing a decline in *H. pylori* research since 2000. However, in 2005, the Nobel Prize was given to the two pioneers in *H. pylori* research J.R. Warren and B.J. Marshall, which provided an incentive for further dedicated original research. Actually, the curve of meeting abstracts shows a peak in 2006, representing a new, steady increase in the number of participating investigators. In addition, *H. pylori* are and remain an invaluable model for chronic infection in gastrointestinal disorders. There is still much to be learned about the epidemiology and pathogenesis of *H. pylori*.

Table 4 Top 21 frequencies of author keywords used

Author keywords	1991–2008 total number of articles (%)	1991–1996 rank (%)	1997–2002 rank (%)	2003–2008 rank (%)
<i>Helicobacter Pylori</i>	5346 (50)	1 (46)	1 (58)	1 (44)
Gastritis	772 (7.2)	3 (16)	2 (6.9)	3 (5.1)
Gastric cancer	661 (6.2)	9 (3.7)	3 (5.0)	2 (7.8)
Duodenal ulcer	454 (4.2)	4 (11)	4 (4.8)	13 (1.8)
Peptic ulcer	380 (3.5)	5 (6.1)	5 (4.2)	7 (2.3)
<i>Helicobacter-pylori</i>	366 (3.4)	2 (26)	1806 (0.024)	N/A
<i>H. pylori</i>	318 (3.0)	337 (0.14)	16 (2.1)	4 (4.4)
Dyspepsia	290 (2.7)	12 (3.3)	6 (3.4)	11 (2.0)
Eradication	276 (2.6)	22 (1.8)	9 (2.9)	5 (2.5)
Omeprazole	266 (2.5)	6 (5.5)	7 (3.1)	30 (1.1)
Stomach	254 (2.4)	15 (2.8)	8 (2.9)	15 (1.8)
Epidemiology	250 (2.3)	12 (3.3)	12 (2.4)	9 (2.0)
Children	248 (2.3)	23 (1.8)	13 (2.3)	6 (2.5)
Gastric ulcer	233 (2.2)	7 (4.9)	18 (2.1)	19 (1.5)
Caga	226 (2.1)	131 (0.35)	10 (2.7)	8 (2.1)
Intestinal metaplasia	212 (2.0)	20 (2.0)	14 (2.2)	14 (1.8)
Clarithromycin	205 (1.9)	40 (1.1)	11 (2.6)	17 (1.6)
Gastrin	182 (1.7)	14 (3.0)	19 (1.8)	25 (1.3)
Metronidazole	174 (1.6)	20 (2.0)	16 (2.1)	30 (1.1)
Apoptosis	171 (1.6)	72 (0.56)	22 (1.6)	12 (1.9)
Inflammation	171 (1.6)	86 (0.49)	27 (1.5)	10 (2.0)

N/A, not available.

International and domestic conferences have also contributed to *H. pylori* research production. There were 10 396 meeting abstracts in SCI Expanded publications presented during the 18-year study period. Seventy-seven percent of meeting abstracts identified by ISI were published in two core journals *Gastroenterology* and *Gut*, which are the official journals of the American Gastroenterological Association and British Society of Gastroenterology. One limitation in our study is that we did not analyze meeting abstracts, which were not identified by ISI. For example, the European *Helicobacter* Study Group was founded in 1987 and established a yearly workshop that has been held in different European cities. A total of 7246 abstracts were presented at European *Helicobacter* Study Group workshops from 1988 to 2007. Another example is the Japanese Society for *Helicobacter* Research meeting, which was established in 1995 and is held annually. The abstracts of this meeting are published in the *Japanese Journal of Helicobacter Research*.

The G7 industrial countries had high productivity of independent articles, with a total of 9597 (62% of all independent articles). Domination in publication from mainstream countries is not surprising, as this pattern has occurred in most scientific fields [9,21]. To a certain extent, the number of research papers reflects the high activity and academic level of these countries [13,22].

Article titles and author keywords supply are some details of the subjects of the articles. Statistical analysis of keywords might aim at discovering directions of science, and may prove important for monitoring developments in science and programs. In the last decade, 'gastric cancer' emerged as the second most common keyword, which implies that the development of 'gastric cancer' study in the field of *H. pylori* research is basically steady and concentrated in the years of this study. KeyWords Plus is usually more concerned with novel research directions

than mature direction in the field [16]. The decrease of the keyword 'gastritis' might have occurred because of the gradual maturity of this orientation in *H. pylori* research. KeyWords Plus analysis showed that a lot of attention was given to 'gastric cancer' and 'duodenal ulcer' in the study period. This indicates that research on *H. pylori* topics related to 'gastric cancer' application to human disease and therapy will undoubtedly remain a hotspot of *H. pylori* research in the future. Actually, some research is now focused on the cancer-preventive effects of *H. pylori* eradication in patients with preneoplastic conditions such as atrophic gastritis and intestinal metaplasia. Some randomized control studies have now reported that *H. pylori* eradication can induce regression of atrophy to some extent [23,24].

Conclusions

This study of *H. pylori* papers showed some points concerning research performance from 1991 to 2008. There were totally 19 080 articles in 1727 journals listed in 122 SCI subject categories. The mainstream research on *H. pylori* was in the clinical gastroenterology, microbiology, and pharmacology fields. *Helicobacter* published the most articles in 2008. The G7, which has a long tradition of research in this field, held the majority of the total world production. By synthetically analyzing the distribution and changes in article titles, author keywords and KeyWords Plus, we described the development of research on *H. pylori*, and predicted the future orientation of *H. pylori* research. It can be concluded that application of *H. pylori* disease therapy, especially research related to 'gastric cancer', is the orientation of *H. pylori* research in the 21st Century. The results of analysis with this bibliometric method can help relevant researchers understand the panorama of global *H. pylori* research, and establish the direction of further research.

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