


Bibliometric Analysis on Global Analgesia in Labor from 2002 to 2021

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Background: Maternal pain during labor is one of the most important factors contributing to increased cesarean delivery rates and poor pregnancy outcomes, and this pain can be managed by labor analgesia. Many studies exist on labor analgesia, and the quantity and quality of these studies have not been reported. Therefore, we aimed to perform a bibliometric analysis of studies from 2002 to 2021.

Methods: We used the Web of Science database to obtain publications related to labor analgesia from January 2002 to December 2021. Various bibliographic information was collected, including country; author; journal; grant; discipline; institution and research hotspot. A total of 4536 papers were included.

Results: A total of 4536 articles were included in the study. The country with the most published articles on labor analgesia and the country of the funding agency was the United States. Most articles were published in the disciplines Anesthesiology and Obstetrics & Gynecology. The journal that published the most articles in this category was International Journal of Obstetric Anesthesia. In addition, we found different research hotspots for labor analgesia in the United States, Japan, and China.

Conclusion: This paper provides a bibliometric analysis of research on labor analgesia and highlights the differences in research hotspots for labor analgesia between countries.

Keywords: labor analgesia, bibliometric analysis, hotspots

Introduction

Women in labor suffer prolonged bouts of severe pain during delivery, leading to an increased risk of complications such as postpartum hemorrhage and postpartum depression.¹ Labor analgesia, both pharmacologic and non-pharmacologic, can promote, support, and protect natural labor and improve the labor experience.² Different modes of labor analgesia may also alter the outcome of labor, maternal expectations and preferences for analgesia should be fully respected and supported, and the decision-making model for labor analgesia is often dominated by a healthcare-led paternalistic or informed consent model.²

For a long time, labor analgesia has been performed by a single epidural injection of a large dose of local anesthesia, which produces analgesia and a short operative time after injection.³ Since then, researchers have diverged in their views on labor analgesia techniques and the emergence of epidural catheters, which solved the problem of repeated epidural puncture operations and reduced maternal postoperative complications.

The concept of drugs for epidural blocks has also often changed, and the addition of opioids to the drugs can reduce the concentration of bupivacaine to 0.065%, which can improve the adverse effects on the maternal lower limbs after delivery. In recent years, new levorotatory isomers of local anesthetics, levoropivacaine and levobupivacaine, have been introduced, which may be less cardiotoxic than bupivacaine.⁴

Remifentanyl is a potent, ultra-short-acting opioid with a rapid onset of action and a rapid drug elimination half-life, able to be metabolized 3–5 minutes after discontinuation of the drug.⁵ Remifentanyl has been shown to cause fewer

maternal and neonatal postoperative complications than other opioid analgesics.⁶ Remifentanyl can cross the placenta, but some countries believe that it can still be used in obstetric anesthesia because it can be rapidly metabolized in the fetus.

With social concerns, labor analgesia should be taken seriously, and labor pains have been developed in various countries and research findings have been reported. However, few of these articles are currently reported for statistical analysis and generalization of research trends. Bibliometric analysis refers to the quantitative and qualitative analysis of literature using theories and methods of metrology and informatics, and reflects the quantity, quality and influence of literature more systematically by quantifying and analyzing the time of publication, authors, citations, institutions and other factors. A previous bibliometric analysis by Zheng et al analyzed the bibliometric analysis on labor analgesia over the last 30 years,⁷ and the innovation of our study was to analyze the hotspots of research in three countries, the United States, Japan, and China, and to draw clusters by year for comparison, which was not found in previous studies. We used a bibliometric approach to evaluate 4536 forest articles on labor analgesia published from 2002 to 2021, analyzing the nature of these articles, their content, and their changes with respect to time.

Materials and Methods

Search Strategy

We searched the Web of Science database for all publications on labor analgesia from 2002 to 2021, using the subject term “labor analgesia” and the article type “article review the article type was “article review”. A total of 4536 articles were collected, including their country, author, journal of publication, grant, discipline, and institution. We did not have any exclusion criteria. Two reviewers reviewed the literature for relevant articles independently. We limited the type of paper as article and review which include ‘basic research, clinical trials and case report’, but excluded publications as follows: letter (n = 481), meeting abstract (n = 536), proceeding paper (n = 241), editorial material (n = 239), note (n = 36), correction (n = 19), early access (n = 6), correction, addition (n = 3), retracted publication (n = 2), Biographical-item (n = 1), new item (n = 1) and reprint (n = 1). We filter the retrieved articles by the process shown in Figure 1.

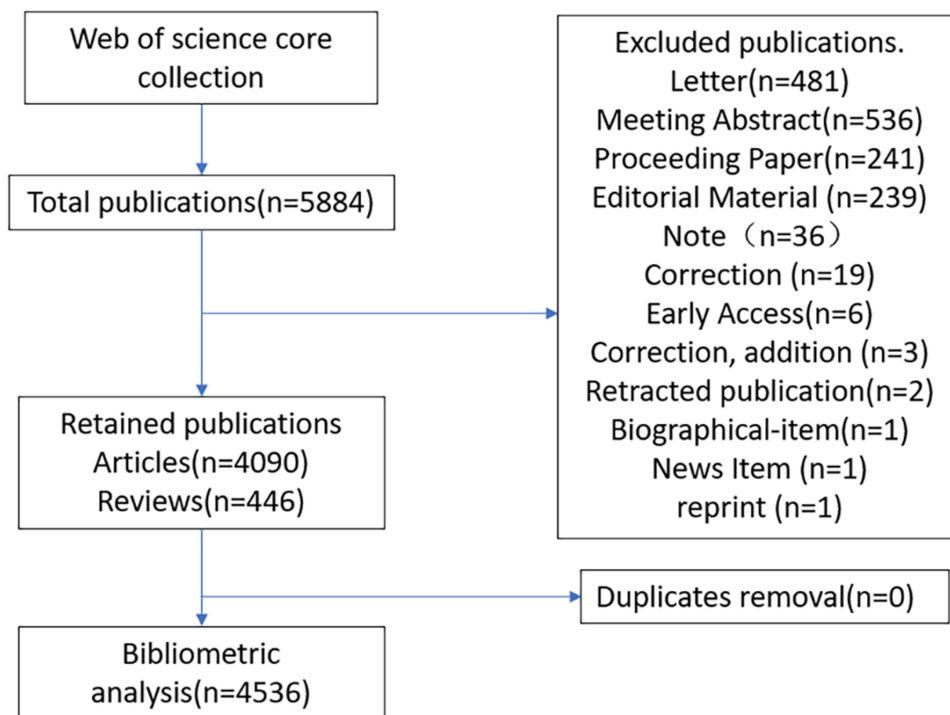


Figure 1 Search Flow Chart.

Statistical Analysis

We used SPSS software (version 22.0; IBM Corporation, Armonk, NY, USA) for statistical analysis. The data were expressed as the mean (range) or number (%). We analyzed categorical variables using χ^2 test and continuous variables with an independent-sample *t* test. We calculated correlation coefficients (*r*) and *P* values using Spearman's test. A *P* value of less than 0.05 was considered statistically significant.

Results

Year and Country of Publication

The country with the most published articles on labor analgesia was the United States (*n*=1375), much higher than the United Kingdom (*n*=515), which had the second highest number of publications, and Canada (*n*=296), the third, but the United Kingdom had the highest average citations per article of these three countries, with an average of 30.2 citations per article. The country with the highest average number of citations per article of all countries was Ireland, with an average of 40.94 citations per article, despite only 70 articles being published between 2002 and 2021. See [Table 1](#).

Among these 20 years 2021 had the highest number of publications (*n*=171), followed by 2017 (*n*=168) and 2019 (*n*=165). As shown in [Figure 2A](#), the country with the highest number of publications per year continues to be the United States. In addition, we summarized the collaborative relationship between different countries in [Figure 2B](#), and it was found that there were more collaborative treatises with USA; Canada and UK, followed by countries with more publications such as Australia and France. The United States leads the way in terms of volume of publications, annual publications and partnerships.

Authors and Institutions

We also counted the corresponding authors of these articles and recorded their H-index to better assess the number and level of academic output of the researchers, with the most frequent corresponding author being Sng, Ban Leong of KK Women's & Children's Hospital (*n*=21; H-index=8). The next highest number of corresponding authors was Carvalho, Berta, B Braun Avitum Portugal (*n*=14; H-index=8) and Orbach-Zinger, S, Sackler Faculty of Medicine (*n*=10; H-index=5). The highest H-indexes among the top 20 authors counted were also Sng, Ban Leong and Carvalho, Berta.

Table 1 Ranking of the Number of Articles Issued by Different Countries

Ranking	Country	Number of Articles Issued	Number of Citations	Average Citations Per Article
1	USA	1375	33,426	24.31
2	ENGLAND	515	15,551	30.2
3	CANADA	296	8270	27.94
4	CHINA MAINLAND	279	1593	5.71
5	AUSTRALIA	277	6121	22.1
6	FRANCE	247	3085	12.49
7	ISRAEL	197	2477	12.57
8	GERMANY	161	2739	17.01
9	SWEDEN	160	4892	30.58
10	ITALY	155	2457	15.85
11	BELGIUM	103	2613	25.37
12	NETHERLANDS	98	1767	18.03
13	SWITZERLAND	92	2127	23.12
14	SINGAPORE	76	1108	14.58
15	SPAIN	74	642	8.68
16	TURKEY	74	567	7.66
17	IRELAND	70	2866	40.94
18	BRAZIL	69	640	9.28
19	FINLAND	65	1452	22.34
20	JAPAN	63	895	14.21

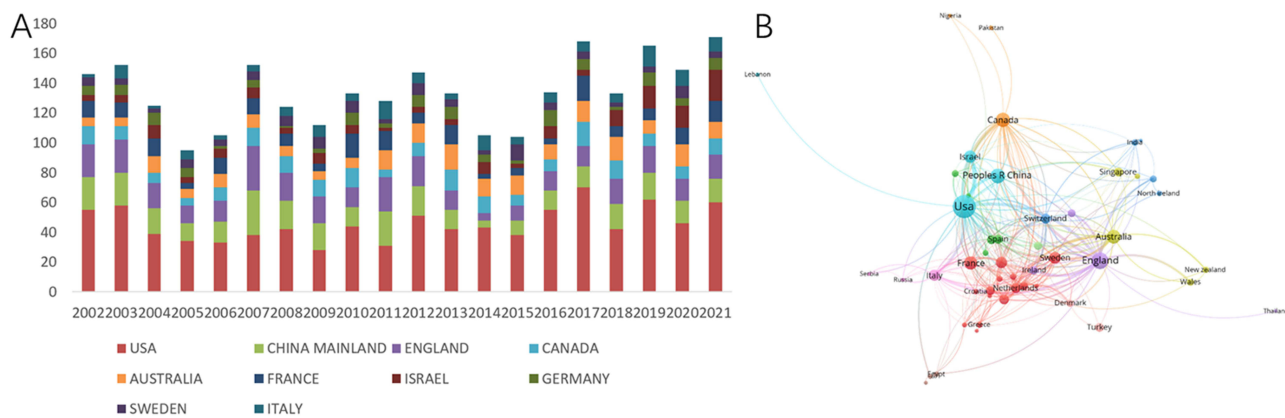


Figure 2 Statistical chart of the top 20 countries in terms of number of articles published on analgesia in childbirth. **Notes:** (A) Shows the number of articles issued by each country in different years. (B) shows the partnership of articles issued by each country, the larger the area of the dot means more partnership.

We counted the number of articles published by different institutions and found that the two most published institutions were Harvard University (n=154; H-index=39) and Brigham & Women’s Hospital (n=115; H-index=37) in the United States, followed by the French institution UDICE-French Research Universities (n=115; H-index=23). We also summarized the graph of collaborative relationships between different institutions, as shown in Figure 3, with more collaborative institutions in Australia and more articles collaborated by institutions in the United States. See Table 2.

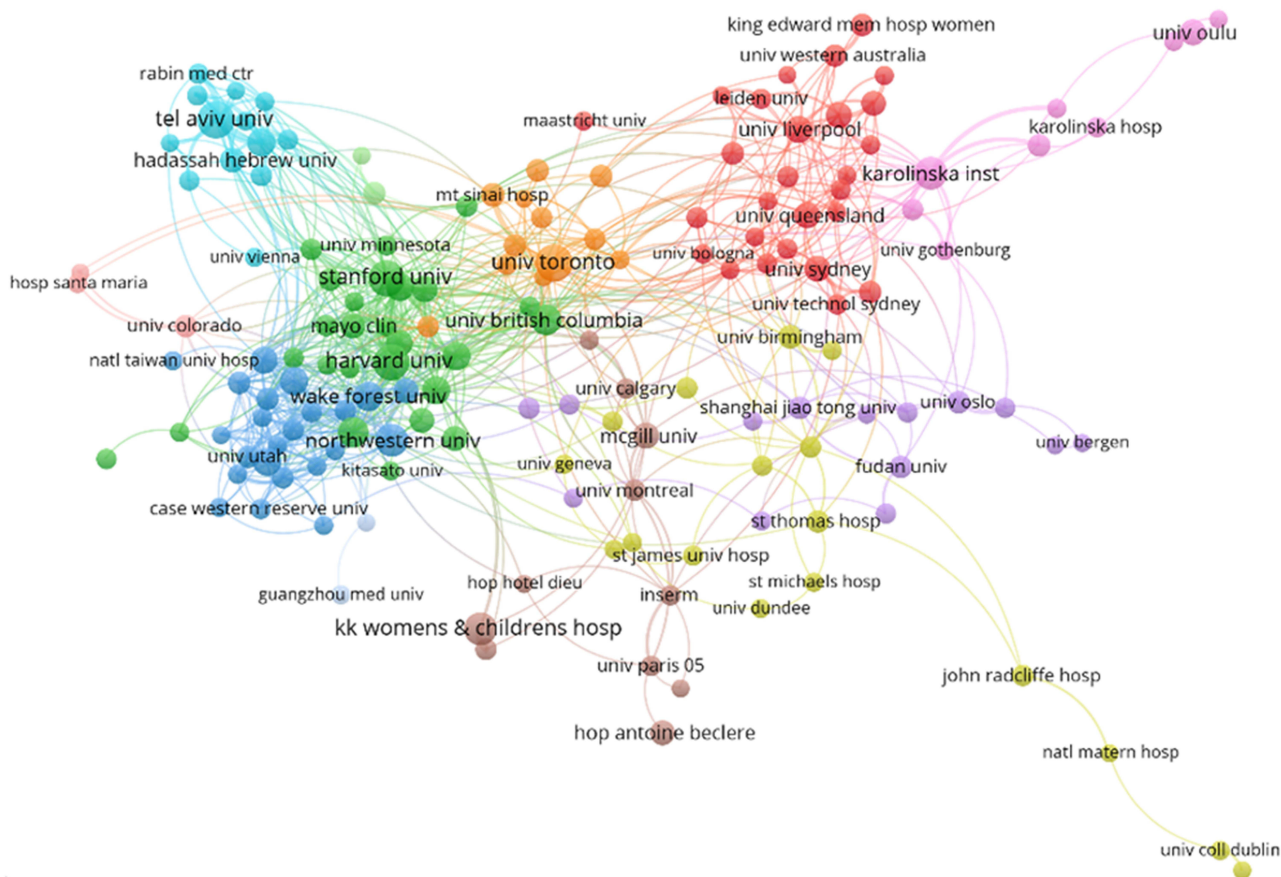


Figure 3 For labor analgesia without using the partnership map between institutions. **Note:** Larger dots indicate more collaborations.

Table 2 Ranking of the 20 Institutions with the Highest Number of Publications

Ranking	Author Institution	Number of Articles Issued	Number of Citations	Average Citations Per Article	H-Index
1.	Harvard University	154	4351	28.25	39
2.	Brigham & Women's Hospital	115	3585	31.17	37
3.	UDICE-French Research Universities	115	1821	15.83	23
4.	Assistance Publique Hopitaux Paris (APHP)	113	1574	13.93	21
5.	University of Toronto	103	3415	33.16	27
6.	Tel Aviv University	96	1205	12.55	19
7.	University of California System	93	2315	24.89	26
8.	Imperial College London	92	2605	28.32	30
9.	Sackler Faculty of Medicine	92	1193	12.97	19
10.	University of London	89	3182	35.75	31
11.	Karolinska Institutet	83	2569	30.95	29
12.	University of Texas System	82	3351	40.87	33
13.	Stanford University	80	2020	25.25	23
14.	Hebrew University of Jerusalem	78	808	10.36	16
15.	KK Women's & Children's Hospital	70	1018	14.54	19
16.	Wake Forest University	65	1971	30.32	27
17.	Columbia University	64	1136	17.75	20
18.	Northwestern University	62	1488	24	20
19.	Universite de Paris	61	938	15.38	16
20.	Institut National de la Sante et de la Recherche Medicale (Inserm)	56	1184	21.14	18

Subjects and Funds

We analyzed all included article disciplines and funds and categorized them statistically. The most predominant disciplines issuing articles were anesthesiology (39%) and obstetrics and gynecology (35%), accounting for more than half of all articles. Other disciplines included NURSING (6%) and PEDIATRICS (4). More detailed data are presented in Figure 4.

We also summarized the 10 funders that funded the most birth analgesia postings, as shown in Table 3. The United States Department of Health Human Services funded the largest number of publications with 167. This was followed by the Nih Eunice Kennedy Shriver National Institute Of Child Health Human Development Nichd (n=67) and the European Commission (n=42).

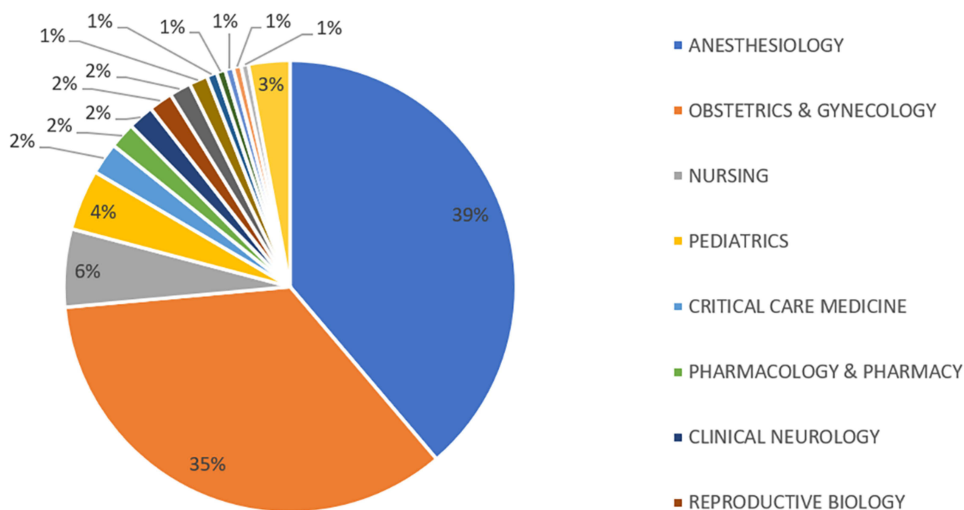


Figure 4 Distribution of articles published on labor analgesia in different disciplines.

Table 3 The 10 Most Funded Funds and Recipient Institutions for Articles on Labor Analgesia

Ranking	Fund Supporting Organizations	Number of Articles Issued	The 5 Recipients with the Highest Number of Articles Issued	Number of Articles Issued
1	United States Department Of Health Human Services	167	HARVARD UNIVERSITY UDICE FRENCH RESEARCH UNIVERSITIES BRIGHAM WOMEN S HOSPITAL ASSISTANCE PUBLIQUE HOPITAUX PARIS APHP UNIVERSITY OF TORONTO	154 116 115 113 106
2	Nih Eunice Kennedy Shriver National Institute Of Child Health Human Development Nihhd	67	NATIONAL INSTITUTES OF HEALTH NIH USA NIH EUNICE KENNEDY SHRIVER NATIONAL INSTITUTE OF CHILD HEALTH HUMAN DEVELOPMENT NICHHD HARVARD UNIVERSITY BRIGHAM WOMEN S HOSPITAL UNIVERSITY OF TEXAS SYSTEM	14 14 12 11 10
3	European Commission	42	KAROLINSKA INSTITUTET UPPSALA UNIVERSITY KAROLINSKA UNIVERSITY HOSPITAL SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES UNIVERSITY OF SKOVDE	16 9 4 4 3
4	National Natural Science Foundation Of China Nsfc	32	FUDAN UNIVERSITY GUANGZHOU MEDICAL UNIVERSITY ZHEJIANG UNIVERSITY NANJING MEDICAL UNIVERSITY GUANGXI UNIVERSITY OF CHINESE MEDICINE WAKE FOREST UNIVERSITY	6 4 4 3 2 7
5	Nih National Institute Of General Medical Sciences Nigms	27	UNIVERSITY OF CALIFORNIA SYSTEM UNIVERSITY OF CALIFORNIA DAVIS UNIVERSITY OF LOUISVILLE PENNSYLVANIA COMMONWEALTH SYSTEM OF HIGHER EDUCATION PCSHE UNIVERSITY OF SYDNEY	6 5 4 3 10
6	National Health And Medical Research Council Nhmrc Of Australia	22	KOLLING INSTITUTE OF MEDICAL RESEARCH UNIVERSITY OF ADELAIDE UNIVERSITY OF TECHNOLOGY SYDNEY MATER RESEARCH	5 5 5 4
7	Swedish Research Council	20	KAROLINSKA INSTITUTET UPPSALA UNIVERSITY KAROLINSKA UNIVERSITY HOSPITAL SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES UNIVERSITY OF SKOVDE	16 8 4 4 3
8	Nih National Center For Advancing Translational Sciences Ncats	18	UNIVERSITY OF TEXAS SYSTEM FEINBERG SCHOOL OF MEDICINE MEDICAL UNIVERSITY OF SOUTH CAROLINA NORTHWESTERN UNIVERSITY	4 3 3 3

(Continued)

Table 3 (Continued).

Ranking	Fund Supporting Organizations	Number of Articles Issued	The 5 Recipients with the Highest Number of Articles Issued	Number of Articles Issued
9	Canadian Institutes Of Health Research Cihr	16	PENNSYLVANIA COMMONWEALTH SYSTEM OF HIGHER EDUCATION PCSHE	3
			UNIVERSITY OF BRITISH COLUMBIA	6
			CHILD FAMILY RESEARCH INSTITUTE	3
			UNIVERSITY OF TORONTO	3
			DALHOUSIE UNIVERSITY	2
10	Nih National Center For Research Resources Ncrr	16	MCGILL UNIVERSITY	2
			IVERSITY OF CALIFORNIA DAVIS	3
			UNIVERSITY OF CALIFORNIA SYSTEM	3
			UNIVERSITY OF VERMONT	3
			NATIONAL INSTITUTES OF HEALTH NIH USA	2
			NIH EUNICE KENNEDY SHRIVER NATIONAL INSTITUTE OF CHILD HEALTH HUMAN DEVELOPMENT NICHD	2

In all these articles, most of the disciplines are anesthesiology and obstetrics and gynecology. The United States Department of Health and Human Services funded the most articles.

Journal Analysis

Secondly, we collected and counted the journals in which all articles were published, and we found that the journal that published the most articles in this category was *International Journal of Obstetric Anesthesia*, with 357 articles and 12.36 citations per article. In second place is *Anesthesia and Analgesia*, with 323 articles, by the highest number of citations two 9182, with an average of 28.43 citations per article. The third is *Anesthesiology*, with 160 publications, 6659 citations, and the highest average of 41.62 citations per article. More specific information is presented in [Table 4](#). We also summarized the number of publications in each journal by year, and the number of publications in these journals has decreased significantly in recent years compared to the previous decade, but the proportion of publications in each journal has not changed significantly. More specific values are shown in [Figure 5](#).

Table 4 Names of the Top 20 Journals in Terms of Number of Articles Published and Their Number of Articles Published

Ranking	Name	Number of Articles Issued	Number of Citations	Average Citations per Article	IF	Journal Division
1.	INTERNATIONAL JOURNAL OF OBSTETRIC ANESTHESIA	357	4412	12.36	3.282	Q2
2.	ANESTHESIA AND ANALGESIA	323	9182	28.43	6.627	Q1
3.	ANESTHESIOLOGY	160	6659	41.62	8.986	Q1
4.	BRITISH JOURNAL OF ANAESTHESIA	138	3918	28.39	11.719	Q1
5.	CANADIAN JOURNAL OF ANAESTHESIA-JOURNAL CANADIEN D ANESTHESIE	127	2412	18.99	n/a	n/a
6.	ANAESTHESIA	124	2565	20.69	12.893	Q1
7.	AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY	109	5002	45.89	10.693	Q1
8.	OBSTETRICS AND GYNECOLOGY	107	5991	55.99	7.623	Q1
9.	REGIONAL ANESTHESIA AND PAIN MEDICINE	87	1449	16.66	5.564	Q2
10.	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	85	5355	63	12.008	Q1

(Continued)

Table 4 (Continued).

Ranking	Name	Number of Articles Issued	Number of Citations	Average Citations per Article	IF	Journal Division
11.	ACTA ANAESTHESIOLOGICA SCANDINAVICA	85	1253	14.74	2.274	Q4
12.	JOURNAL OF MATERNAL-FETAL & NEONATAL MEDICINE	85	634	7.46	2.323	Q3
13.	JOURNAL OF CLINICAL ANESTHESIA	79	947	11.99	9.375	Q1
14.	ACTA OBSTETRICIA ET GYNECOLOGICA SCANDINAVICA	76	1557	20.49	4.544	Q1
15.	BMC PREGNANCY AND CHILDBIRTH	76	607	7.99	3.105	Q2
16.	ANAESTHESIA AND INTENSIVE CARE	67	748	11.16	1.512	Q4
17.	BIRTH-ISSUES IN PERINATAL CARE	64	1879	29.36	3.081	Q1
18.	BJOG-AN INTERNATIONAL JOURNAL OF OBSTETRICS AND GYNAECOLOGY	63	2379	37.76	7.331	Q1
19.	ANNALES FRANCAISES D ANESTHESIE ET DE REANIMATION	63	317		n/a	n/a
20.	ARCHIVES OF GYNECOLOGY AND OBSTETRICS	56	420	7.5	2.493	Q3

Citation

We summarized the citations of the included articles, and the 20 most cited articles are shown in Table 5. The most cited article was Clinical pharmacology of tramadol by Grond, S,⁸ which was cited 755 times. This was followed by Pain and women’s satisfaction with the experience of childbirth: A systematic review by Hodnett, ED⁹ (cited 586 times) and Midwife-led by Sandall, J continuity models versus other models of care for childbearing women¹⁰ (cited 530 times). The 20 publications included one basic medical study; nine retrospective clinical studies; two review articles and eight systematic reviews. More detailed information is shown in Figure 6 and Table 5.

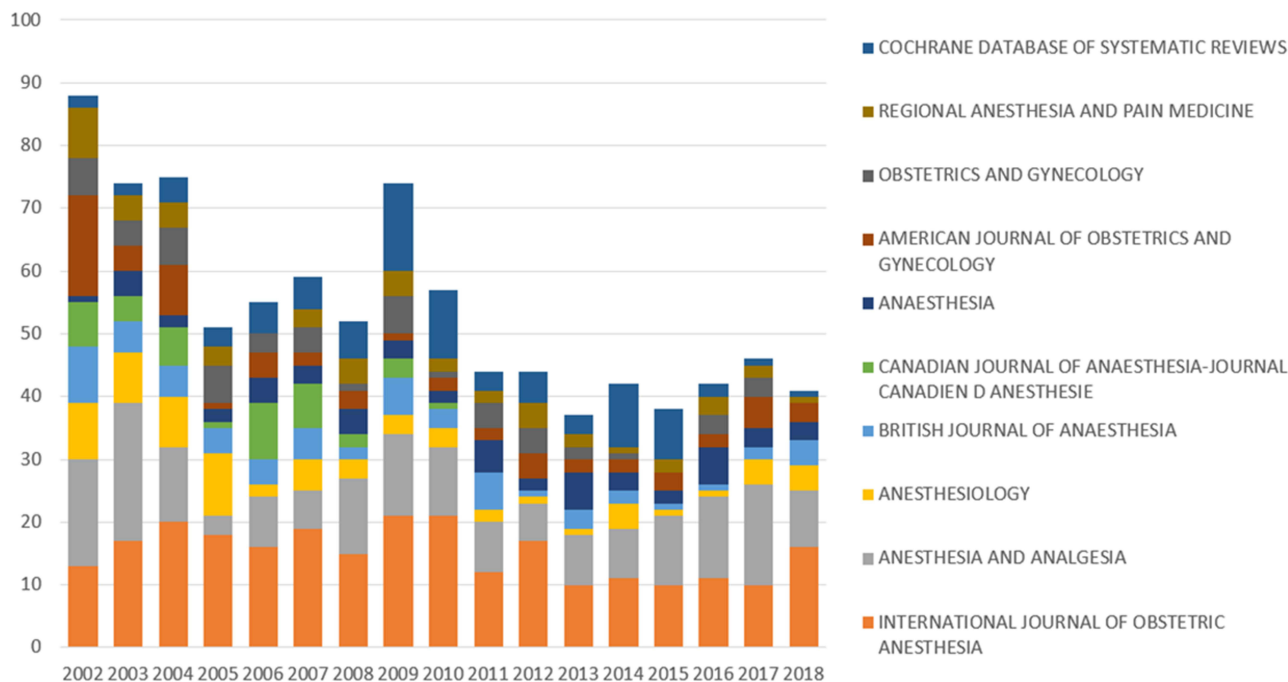


Figure 5 Annual distribution of articles on labor analgesia published in different journals.

Table 5 Information on the Top 20 Cited Articles

Ranking	Title	Corresponding Author	Organization	Journal	Years	Number of Citations	Type
1.	Clinical pharmacology of tramadol	Grond, S	Univ Halle Wittenberg	CLINICAL PHARMACOKINETICS	2004	755	Basic medical study
2.	Pain and women's satisfaction with the experience of childbirth: A systematic review	Hodnett, ED	Maternal Child Nursing Res Unit	AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY	2002	586	Systematic review
3.	Midwife-led continuity models versus other models of care for childbearing women	Sandall, J	St Thomas Hosp	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2013	530	Systematic review
4.	Risk factors for suboptimal infant breastfeeding behavior, delayed onset of lactation, and excess neonatal weight loss	Dewey, KG	Univ Calif Davis	PEDIATRICS	2003	469	Retrospective clinical studies
5.	Preventing the First Cesarean Delivery Summary of a Joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, and American College of Obstetricians and Gynecologists Workshop	Spong, CY	Pregnancy & Perinatol Branch, NIH	OBSTETRICS AND GYNECOLOGY	2012	443	Review articles
6.	Contemporary Patterns of Spontaneous Labor With Normal Neonatal Outcomes	Zhang, J	Epidemiol Branch, NIH	OBSTETRICS AND GYNECOLOGY	2010	419	Retrospective clinical studies
7.	A negative birth experience: Prevalence and risk factors in a national sample	Waldenstrom, U	Karolinska Institutet	BIRTH-ISSUES IN PERINATAL CARE	2004	388	Retrospective clinical studies
8.	Epidural versus non-epidural or no analgesia in labour	Anim-Somuah, M	Tameside Hosp NHS Fdn Trust	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2011	365	Systematic Review
9.	Perinatal factors and the development of autism - A population study	Glasson, EJ	Univ Western Australia	ARCHIVES OF GENERAL PSYCHIATRY	2004	349	Retrospective clinical studies

(Continued)

Table 5 (Continued).

Ranking	Title	Corresponding Author	Organization	Journal	Years	Number of Citations	Type
10.	THE EFFECT OF INTRAPARTUM EPIDURAL ANALGESIA ON NULLIPAROUS LABOR - A RANDOMIZED, CONTROLLED, PROSPECTIVE TRIAL	THORP, JA	ST LUKES HOSP	AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY	1993	336	Retrospective clinical studies
11.	Continuous support for women during childbirth	Hodnett, ED	Univ Toronto	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2013	326	Systematic Review
12.	Continuous support for women during childbirth	Bohren, MA	WHO, Dept Reprod Hlth & Res	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2017	316	Systematic Review
13.	Pain management for women in labour: an overview of systematic reviews	Neilson, JP	Univ Liverpool	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2012	287	Systematic Review
14.	Midwife-led versus other models of care for childbearing women	Sandall, J	Kings Coll London	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2008	274	Systematic Review
15.	Continuous support for women during childbirth (Withdrawn Paper. 2007, art. no. CD003766)	Hodnett, ED	Univ Toronto	COCHRANE DATABASE OF SYSTEMATIC REVIEWS	2007	270	Systematic Review
16.	Relative analgesic potencies of ropivacaine and bupivacaine for epidural analgesia in labor - Implications for therapeutic indexes	Polley, LS	Mott Hosp	ANESTHESIOLOGY	1999	261	Retrospective clinical studies
17.	Bishop score and risk of cesarean delivery after induction of labor in nulliparous women	Vrouenraets, FPJM	Univ Limburg	OBSTETRICS AND GYNECOLOGY	2005	259	Retrospective clinical studies
18.	Advances in and limitations of up-and-down methodology - A precis of clinical use, study design, and dose estimation in anesthesia research	Pace, NL	Univ Utah	ANESTHESIOLOGY	2007	249	Review articles
19.	Risk of cesarean delivery with elective induction of labor at term in nulliparous women	Seyb, ST	Northwestern University	OBSTETRICS AND GYNECOLOGY	1999	246	Retrospective clinical studies
20.	Obstetric events leading to anal sphincter damage	O'Herlihy, C	Univ Coll Dublin	OBSTETRICS AND GYNECOLOGY	1998	239	Retrospective clinical studies

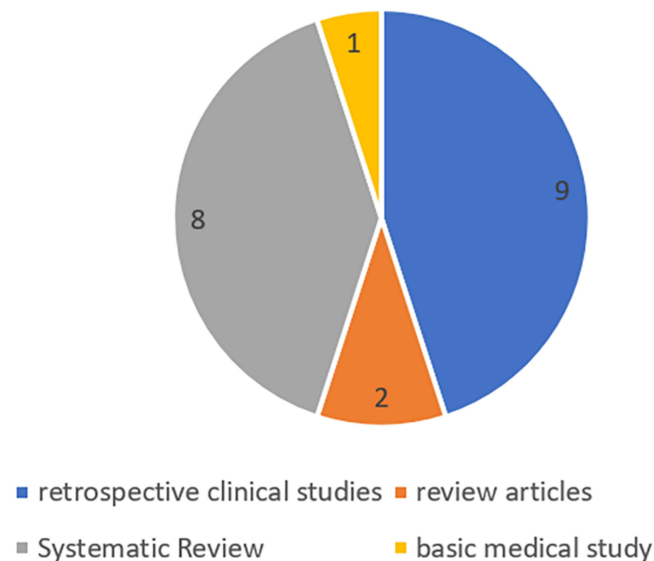


Figure 6 Types of articles with the top 20 citations for labor analgesia.

Theme Analysis

We summarize the hot topics of recent research on labor analgesia in the United States and Asian countries. For the US research hotspots, bupivacaine; infusion anesthesia, etc. were mostly studied until 2010, after which epidural analgesia became the main research hotspot until around 2015, when perioperative management and possible risks became the main content of researchers' thesis. We selected Japan and China as the Asian countries to analyze. The research hotspots in Japan before 2010 were like those in the United States, including bupivacaine and infusion anesthesia, with the difference that fentanyl also occupied a large part of the publications. There are significantly fewer articles on labor analgesia in Japan than in China and the United States. However, in the limited research found around 2015 there were many studies on nulliparous women in labor pain, which is a more unique point among the three countries. Compared with Japan, the number of publications in China appears to be more numerous and the research directions are richer. The research hotspot for labor analgesia in China remained focused on epidural anesthesia after 2015. Unlike the first two, China has recently started to study the effects of psychiatric factors, such as anxiety and depression, on labor analgesia, as well as the effects of different anesthetic drugs on labor analgesia, such as ropivacaine, bupivacaine, and dexmedetomidine. More specific results are shown in [Figure 7](#).

Discussion

Labor pain is a complex physiological and psychological phenomenon that occurs during labor and delivery and is related to the body's own biochemical and physical basis, as well as having an individual emotional component. Labor pains are long-lasting and of high pain level. The main causes of labor pain include contraction of the smooth muscles of the uterus and dilatation of the cervix during labor, compression and dilatation of the rectum, pelvic floor, and soft tissues of the perineum by the fetus. Labor pain can cause maternal respiratory alkalosis, maternal and fetal hypoxia, and induce adverse events such as eclampsia and cardiac arrhythmias.

When analyzing the countries where these articles were published, we found that the United States is still the country with the most articles published in this area, with the highest number of citations. We found that the two highest H-index researchers were not from the United States, probably because there are more researchers on labor analgesia in the United States and the resources are more fragmented, and the resources are not concentrated on one researcher, but on the research institution such as Harvard University (H-index 39).

Compared to some of the world's leading countries, China has a high number of publications but a large gap in total citations, average citations per item and H-index. With economic growth, government investment in the healthcare sector

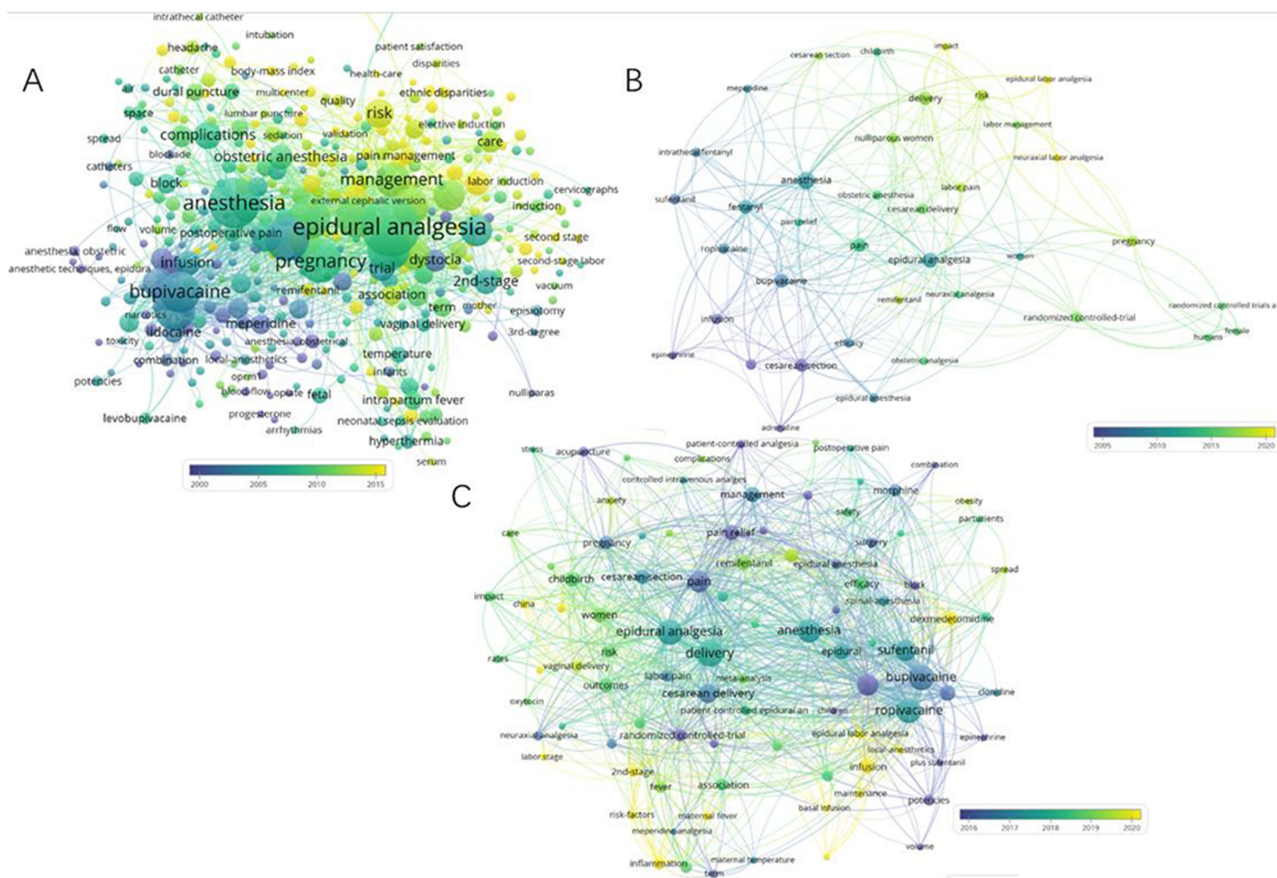


Figure 7 Hotspots of research on labor analgesia in the United States, Japan and China in recent years.

Notes: Larger circles represent a greater number of publications. Different colors indicate different years of publication. **(A)** shows the clustering map of research hotspots in the United States; **(B)** shows the clustering map of research hotspots in Japan; **(C)** shows the clustering map of research hotspots in China.

and a growing population base, a favorable environment for research is provided. Based on these advantages, China may provide a strong support to the world in the future.

In our study, we also summarized all high-citation articles from 2002 to 2021 and summarized recent research hotspots on labor analgesia in the United States, Japan, and China. We mapped the research hotspots by year and tried to relate them to the highly cited literature. We found that around 2010, epidural analgesia became a common research hotspot in all three countries, with many clinical studies on the use of epidural anesthesia for labor analgesia. Intradural labor analgesia is currently recognized as the most effective and widely used method of labor analgesia in clinical practice. Modern obstetric anesthesiology emphasizes the effective improvement of labor pain using minimal doses of intrathecal anesthetics,¹¹ thus maximizing analgesic effects and minimizing adverse effects on mother and child. Currently, there are three types of intrathecal anesthesia for labor analgesia: epidural, combined lumbar-epidural, and continuous lumbar anesthesia. Epidural anesthesia has a high dosage of drugs, slow onset of pain, and may block movement. The epidural anesthesia has many drugs, a slow onset of effect, and may block the motor nerve, but it lasts for a long time and can achieve continuous analgesia during labor. The epidural can be used to provide continuous analgesia during labor. To complement the advantages of lumbar and epidural analgesia. During labor, lumbar anesthesia is used first for rapid onset of analgesia, and then continuous epidural anesthesia is used for maintenance. In the early part of the first stage of labor, lumbar anesthesia and analgesia can be used alone with opioids, and the analgesic effect is satisfactory without motor blockade. However, analgesia is insufficient in the late stage of labor. The use of local anesthetics plus opioids for lumbar anesthesia analgesia has better analgesic effect and longer maintenance time than local anesthetics or opioids alone. Low concentration of local anesthetics plus opioids for epidural analgesia can reduce the concentration of local anesthetics and reduce the number of local anesthetics. In conclusion, intradural anesthesia for

labor analgesia is currently considered safe and effective, but there are still many issues that need to be studied, and the adverse effects of the drugs used need continued attention. Intradural anesthesia and epidural analgesia are still hot spots in the world of research, and we expect larger cohort studies.

The research hotspots also vary greatly between countries, and for the United States, in recent years, the research hotspots have begun to shift towards the perioperative management of maternity and possible risks. We then analyzed some of the articles that were highly cited in the text, the study by Kathryn G et al¹² that described risk factors for feeding behavior in the perioperative and postpartum period, which is the same research hotspot as in the United States in recent years and could be the reason for the fourth highest number of citations in this article. In this article it was elaborated that early lactation and infant weight loss were associated with fetal gestation, number of deliveries, and no other factors such as mode of delivery and analgesic medications. The group with the lowest postpartum risk factors was multiple births and drug-free deliveries. In another highly cited literature⁹ a systematic evaluation of pain and women's satisfaction with childbirth was conducted. This article included 137 reports containing more than 14,000 women from 9 countries. For the aspect of labor analgesia, the researchers illustrated that for women with prenatal anxiety usually had low satisfaction after the procedure, while the highest satisfaction was among those women who did not use pain medication. In another study included in¹³ it was illustrated¹⁴ that when women have enough said in their own decision making, the probability of satisfaction is higher than the effect of surgical analgesia on them. So, it is easy to see that studies on labor analgesia in the United States tend to consider pain relief and medical interventions during labor as having much less impact on maternal satisfaction than perioperative care for maternal management and emotional aspects.

In contrast to the US, recent research in China has focused on the effects of anxiety and depression on childbirth. During pregnancy, delivery, and the puerperium, women are under great physical and mental stress. The process of childbirth is a persistent and intense source of stress for the mother, and the interaction between her poor mental state and labor pain creates a vicious cycle that induces a stress response that may threaten the health of the mother and child during delivery. Some Chinese scholars have reported that many factors contribute to the failure of epidural anesthesia, including the choice of drug dosage, type and mode of delivery, and timing. Among them, maternal psychological factors are important influencing factors. Not only that, anxious and depressed emotional state can have a great impact on postpartum hemorrhage.^{15,16} The Japanese study on nulliparous women focused on the effect of continuous background infusion (CBI) on Patient-controlled epidural analgesia (PCRA). A study by T Okutomi et al¹⁷ concluded that when nulliparous women use background infusion, it reduces the amount of PCEA used, but does not reduce the total amount of ropivacaine and fentanyl used per hour after the start of the procedure. However, at the same time, other studies concluded that PCEA combined with CBI produced better analgesia while reducing the number of doses administered by the anesthesiologist.^{18,19}

For labor analgesia drugs have also been the focus of research in various countries. The most cited article is the use of tramadol,⁸ in which it is mentioned that when tramadol is used for labor analgesia, there is no significant difference in pain relief, labor interval, etc., compared to pethidine, but pethidine shows more and more severe adverse effects.²⁰ In some other studies tramadol was found to have no respiratory depressant effect on the mother and newborn unlike pethidine,^{21–24} therefore tramadol is recommended for obstetric analgesia. Dexmedetomidine has various pharmacological effects such as sedation, analgesia, and anti-sympathetic.²⁵ Some studies have shown that intrathecal application of dexmedetomidine can enhance the analgesic and sedative effects of intrathecal anesthesia, which brings new opportunities for the use of dexmedetomidine for epidural labor analgesia.²⁶ It is also a new research hotspot for labor analgesia in China.

Our study has some limitations; first, the articles included in the high-frequency citations, many excellent articles were published in recent years but were not included due to their short publication time and low total citation frequency. This may lead to the fact that research hotspots that are happening in recent years are not counted by us. Second, we know that the impact factors of journals are related to the citation frequencies of articles, and when they are included in the analysis at the same time, it may bias the article results.

Conclusion

We searched the database for all articles on labor analgesia published from 2002 to 2021. Despite the limitations of this article, we found differences in the hotspots of research on labor analgesia in the United States, China, and Japan, and these differences exist in medication use, paroxysm modes, and perioperative management. These differences may suggest future research directions and communications among different countries.

Author Contributions

Kang Yu and Zhigang Ding are co-first authors. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

All the authors declare no financial support.

Disclosure

The authors declare that they have no conflict of interests.

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