

## Citation classics in main pain research journals

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**Abstract** The number of citations of an article in scientific journals reflects its impact on a specific biomedical field and its recognition in the scientific community. In the present study, we identified and analyzed the characteristics of the 100 most frequently cited articles published between 1970 and 2010 in journals pertaining to pain research and related fields. These articles were identified using the database of the Science Citation Index (1970 to present). The most cited article received 3,017 citations and the least cited article received 302 citations, with a mean of 585 citations per article. These citation classics were published in six high-impact journals, led by *Pain* (84 articles). Of the 100 articles, 39 were observational studies, 25 were review articles, and 20 concerned basic science. The articles originated from 14 countries, with the United States contributing 47 articles; 67 institutions produced these 100 top-cited articles, led by National Institutes of Health of the United States (8 articles) and University College London (6 articles); 18 persons authored 2 or more of the top-cited articles. This analysis of the top citation classics allows for the recognition of major advances in pain research and gives a historical perspective on the scientific progress of this specialty.

**Keywords** Citation classic · Pain · Literature survey

### Introduction

The academic institutions, funding agencies, and the public are currently increasingly interested in assessing the research quality and productivity of individual researchers as an indication of their scholarly excellence. The growing field of analyzing the output of scientific literature is named scientometrics, and it also includes all quantitative analysis.

Citation analysis is a bibliometric field that examines the association between authors and their journal articles [1]. The number of times that articles are cited by other articles is widely used to evaluate the impact of an article or individual author on the scientific community. The argument is that important papers will receive more citations, and therefore a popular and convenient method for assessing the impact of an article is to count its citations.

Recently, many specialties have identified and analyzed the ‘citation classics,’ the top articles most highly cited or the articles referenced more than 100 times, according to the specialty size in their fields [2–5]. In addition, several journals published their own citation classics [6, 7]. In the field of anesthesiology, an analysis of citation classics in anesthetic journals was reported in 2004 [2]. However, the analysis excluded the specialized pain journals. To date, a comprehensive list of the classic citations in the specialty of pain research is not available.

### Materials and methods

Pain is a wide field concerning a series of subjects. In this study, we only focused on the 11 specialized pain journals and the other 22 anesthetic journals selected from the Journal Citation Report (JCR) 2009 for this analysis

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**Table 1** Journals selected for screening

<b>Pain journals</b>	<i>Canadian Journal of Anesthesia</i>
<i>Pain</i>	<i>Acta Anaesthesiologica Scandinavica</i>
<i>European Journal of Pain</i>	<i>Pediatric Anesthesia</i>
<i>Clinical Journal of Pain</i>	<i>European Journal of Anaesthesiology</i>
<i>Journal of Pain</i>	<i>International Journal of Obstetric Anesthesia</i>
<i>Molecular Pain</i>	<i>Journal of Clinical Anesthesia</i>
<i>Journal of Pain and Symptom Management</i>	<i>Anaesthesia and Intensive Care</i>
<i>Pain Management Nursing</i>	<i>Journal of Cardiothoracic and Vascular Anesthesia</i>
<i>Pain Medicine</i>	<i>Schmerz</i>
<i>Journal of Headache and Pain</i>	<i>Minerva Anestesiologica</i>
<i>Journal of Musculoskeletal Pain</i>	<i>Anaesthesist</i>
<i>Journal of Orofacial Pain</i>	<i>Anesthesiologie &amp; Intensivmedizin</i>
<b>Anesthesiology journals</b>	<i>Journal of Anesthesia</i>
<i>Anesthesiology</i>	<i>Annales Françaises d'Anesthésie et de Réanimation</i>
<i>Regional Anesthesia and Pain Medicine</i>	<i>Anesthesiologie Intensivmedizin</i>
<i>British Journal of Anaesthesia</i>	<i>Notfallmedizin Schmerztherapie</i>
<i>Anesthesia &amp; Analgesia</i>	<i>Douleur et Analgesie</i>
<i>Anaesthesia</i>	
<i>Journal of Neurosurgical Anesthesiology</i>	

(Table 1). The most frequently cited articles related to pain research published in the 33 analyzed journals' years were searched and identified in the database of the Science Citation Index (SCI, 1970 to present). The search covered the 11 pain journals; further, the search in the anesthetic journals was under the terms 'pain' or 'analgesia.' More than 800 articles were cited 100 times and more, and the top 100 highly cited articles in this list were selected for further analysis. The titles and abstracts of the articles were reviewed to estimate whether they are related to pain research. We analyzed the articles and calculated the data according to the following predefined items: number of citations, publication time, country of origin, institution, journal, publication type of article (e.g., basic science, observational study), and authorship (only considering the corresponding, first, and second authors).

## Results

Using the SCI update to December 31, 2010, 865 articles cited 100 times or more related to pain research were retrieved. We included the top 100 most frequently cited

articles from this list and ranked them based on the number of citations they received (Table 2). The most frequently cited article received 3,017 citations and the least frequently cited article received 302 citations. The mean number of citations per article was 585. Ten articles were cited more than 1,000 times.

The top 100 frequently cited articles were published from 1971 to 2005. The decade from 1990 to 1999 produced the most citation classics with 45 articles, followed by 31 articles from 1980 to 1989, 18 articles from 1970 to 1979, and 6 from 2001 to 2010. The most classic articles published within given years were 8 articles in both 1992 and 1993. The top 5 citation classics in every decade are listed in Table 3.

The top 100 cited articles were all published in six high-impact journals (Table 4), led by *Pain* (84 articles), followed by *Anesthesia & Analgesia* (7 articles), *Anesthesiology* (6 articles), *Anaesthesia* (1 article), *European Journal of Pain* (1 article), and *Clinical Journal of Pain* (1 article).

The 100 top-cited articles originated from 14 countries, with the United States producing 47 articles, followed by UK with 12 and Canada with 10 (Table 5); 27 articles were from non-English-speaking countries.

In total, 67 institutions reported these 100 classic papers. Among them, 17 institutions published 2 or more top-cited articles (Table 6), led by the National Institutes of Health of the United States (8 articles), followed by University College London (6 articles) and McGill University (4 articles).

Fourteen articles were authored by a single author and 25 articles by two authors; 18 authors published 2 or more of the top-cited articles. Table 7 presents a list of these most frequent authors, which is obviously led by D.D. Price, who authored 6 classic papers and P.D. Wall, who authored 4 classic papers.

Of the 100 articles, 39 were observational studies, 25 were review articles, and 20 concerned basic science. The other 16 papers included 7 systematic reviews, 6 randomized controlled trials, 2 guidelines, and 1 editorial (Table 8).

## Discussion

The number of citations of an individual paper is widely used to assess the impact of the paper and to measure the quality of a journal. Citation analysis helps us recognize important advances in pain research and adds useful perspective on historical developments in our specialty [8]. It can also supply quantitative information about authors, institutions, and journals that is helpful to identify classic works and high-impact journals. To the best of our knowledge, this is the first bibliometric analysis to reveal the top citations in the field of pain research.

**Table 2** The top 100 citation classics in pain research

Rank	Article	No. of citations
1	Zimmermann M. Ethical guidelines for investigations of experimental pain in conscious animals. <i>Pain</i> 1983;16:109–10	3,017
2	Melzack R. The McGill Pain Questionnaire: major properties and scoring methods. <i>Pain</i> 1975;1:277–99	2,828
3	Bennett GJ, Xie YK. A peripheral mononeuropathy in rat that produces disorders of pain sensation like those seen in man. <i>Pain</i> 1988;33:87–107	2,014
4	Hargreaves K, Dubner R, Brown F, et al. A new and sensitive method for measuring thermal nociception in cutaneous hyperalgesia. <i>Pain</i> 1988;32:77–88	1,958
5	Kim SH, Chung JM. An experimental model for peripheral neuropathy produced by segmental spinal nerve ligation in the rat. <i>Pain</i> 1992;50:355–63	1,396
6	Scott J, Huskisson EC. Graphic representation of pain. <i>Pain</i> 1976;2:175–84	1,290
7	Dubuisson D, Dennis SG. The formalin test: a quantitative study of the analgesic effects of morphine, meperidine, and brain stem stimulation in rats and cats. <i>Pain</i> 1977;4:161–74	1,221
8	Melzack R. The short-form McGill Pain Questionnaire. <i>Pain</i> 1987;30:191–7	1,219
9	Coderre TJ, Katz J, Vaccarino AL, et al. Contribution of central neuroplasticity to pathological pain: review of clinical and experimental evidence. <i>Pain</i> 1993;52:259–85	1,210
10	Woolf CJ, Thompson SW. The induction and maintenance of central sensitization is dependent on <i>N</i> -methyl-D-aspartic acid receptor activation; implications for the treatment of post-injury pain hypersensitivity states. <i>Pain</i> 1991;44:293–9	1,085
11	Rosenstiel AK, Keefe FJ. The use of coping strategies in chronic low back pain patients: relationship to patient characteristics and current adjustment. <i>Pain</i> 1983;17:33–44	992
12	Price DD, McGrath PA, Rafii A, et al. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. <i>Pain</i> 1983;17:45–56	975
13	Kerns RD, Turk DC, Rudy TE. The West Haven-Yale Multidimensional Pain Inventory (WHYMPI). <i>Pain</i> 1985;23:345–56	913
14	Jensen MP, Karoly P, Braver S. The measurement of clinical pain intensity: a comparison of six methods. <i>Pain</i> 1986;27:117–26	878
15	Seltzer Z, Dubner R, Shir Y, et al. A novel behavioral model of neuropathic pain disorders produced in rats by partial sciatic nerve injury. <i>Pain</i> 1990;43:205–18	819
16	Tjolsen A, Berge OG, Hunskaar S, et al. The formalin test: an evaluation of the method. <i>Pain</i> 1992;51:5–17	765
17	Waddell G, Newton M, Henderson I, et al. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. <i>Pain</i> 1993;52:157–68	743
18	Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. <i>Pain</i> 1992;50:133–49	733
19	Revill SI, Robinson JO, Rosen M, et al. The reliability of a linear analogue for evaluating pain. <i>Anaesthesia</i> 1976;31:1191–8	729
20	Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. <i>Pain</i> 2000;85:317–32	728
21	Farrar JT, Young JP Jr, LaMoreaux L, et al. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. <i>Pain</i> 2001;94:149–58	720
22	Woolf CJ, Chong MS. Preemptive analgesia—treating postoperative pain by preventing the establishment of central sensitization. <i>Anesth Analg</i> 1993;77:362–79	681
23	Le Bars D, Dickenson AH, Besson JM. Diffuse noxious inhibitory controls (DNIC). I. Effects on dorsal horn convergent neurones in the rat. <i>Pain</i> 1979;6:283–304	677
24	Meller ST, Gebhart GF. Nitric oxide (NO) and nociceptive processing in the spinal cord. <i>Pain</i> 1993;52:127–36	654
25	Hunskaar S, Hole K. The formalin test in mice: dissociation between inflammatory and non-inflammatory pain. <i>Pain</i> 1987;30:103–14	626
26	Mayer DJ, Price DD. Central nervous system mechanisms of analgesia. <i>Pain</i> 1976;2:379–404	623
27	Arner S, Meyerson BA. Lack of analgesic effect of opioids on neuropathic and idiopathic forms of pain. <i>Pain</i> 1988;33:11–23.	589
28	Sindrup SH, Jensen TS. Efficacy of pharmacological treatments of neuropathic pain: an update and effect related to mechanism of drug action. <i>Pain</i> 1999;83:389–400	575
29	Yaksh TL, Rudy TA. Narcotic analgesics: CNS sites and mechanisms of action as revealed by intracerebral injection techniques. <i>Pain</i> 1978;4:299–359	562
30	Wang JK, Nauss LA, Thomas JE. Pain relief by intrathecally applied morphine in man. <i>Anesthesiology</i> 1979;50:149–51	551
31	Yeager MP, Glass DD, Neff RK, et al. Epidural anesthesia and analgesia in high-risk surgical patients. <i>Anesthesiology</i> 1987;66:729–36	538

**Table 2** continued

Rank	Article	No. of citations
32	Yaksh TL. Spinal opiate analgesia: characteristics and principles of action. <i>Pain</i> 1981;11:293–346	537
33	Unruh AM. Gender variations in clinical pain experience. <i>Pain</i> 1996;65:123–67.	530
34	Vlaeyen JW, Kole-Snijders AM, Boeren RG, et al. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. <i>Pain</i> 1995;62:363–72	504
35	Flor H, Fydrich T, Turk DC. Efficacy of multidisciplinary pain treatment centers: a meta-analytic review. <i>Pain</i> 1992;49:221–30	492
36	Daut RL, Cleeland CS, Flanery RC. Development of the Wisconsin Brief Pain Questionnaire to assess pain in cancer and other diseases. <i>Pain</i> 1983;17:197–210	482
37	Stanton-Hicks M, Jänig W, Hassenbusch S, et al. Reflex sympathetic dystrophy: changing concepts and taxonomy. <i>Pain</i> 1995;63:127–33	476
38	Chapman CR, Casey KL, Dubner R, et al. Pain measurement: an overview. <i>Pain</i> 1985;22:1–31	473
39	McQuay HJ, Tramer M, Nye BA, et al. A systematic review of antidepressants in neuropathic pain. <i>Pain</i> 1996;68:217–27	461
40	Fitzgerald M. Capsaicin and sensory neurones—a review. <i>Pain</i> 1983;15:109–30	460
41	Melzack R, Torgerson WS. On the language of pain. <i>Anesthesiology</i> 1971;34(1):50–9	450
42	Serlin RC, Mendoza TR, Nakamura Y, et al. When is cancer pain mild, moderate or severe? Grading pain severity by its interference with function. <i>Pain</i> 1995;61:277–84	447
43	Morley S, Eccleston C, Williams A. Systematic review and meta-analysis of randomized controlled trials of cognitive behaviour therapy and behaviour therapy for chronic pain in adults, excluding headache. <i>Pain</i> 1999;80:1–13	445
44	Gracely RH, Lynch SA, Bennett GJ. Painful neuropathy: altered central processing maintained dynamically by peripheral input. <i>Pain</i> 1992;51:175–94	444
45	Crombez G, Vlaeyen JW, Heuts PH, et al. Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. <i>Pain</i> 1999;80:329–39	440
46	Le Bars D, Dickenson AH, Besson JM. Diffuse noxious inhibitory controls (DNIC). II. Lack of effect on non-convergent neurones, supraspinal involvement and theoretical implications. <i>Pain</i> 1979;6:305–27	436
47	Dickenson AH, Sullivan AF. Subcutaneous formalin-induced activity of dorsal horn neurones in the rat: differential response to an intrathecal opiate administered pre or post formalin. <i>Pain</i> 1987;30:349–60	427
48	Mense S. Nociception from skeletal muscle in relation to clinical muscle pain. <i>Pain</i> 1993;54:241–89	419
49	Liu S, Carpenter RL, Neal JM. Epidural anesthesia and analgesia. Their role in postoperative outcome. <i>Anesthesiology</i> 1995;82:1474–506	415
50	Mao J, Price DD, Mayer DJ. Mechanisms of hyperalgesia and morphine tolerance: a current view of their possible interactions. <i>Pain</i> 1995;62:259–74	413
51	Portenoy RK, Foley KM, Inturrisi CE. The nature of opioid responsiveness and its implications for neuropathic pain: new hypotheses derived from studies of opioid infusions. <i>Pain</i> 1990;43:273–86	406
52	Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. <i>Pain</i> 1983;16:87–101	403
53	Yaksh TL. Behavioral and autonomic correlates of the tactile evoked allodynia produced by spinal glycine inhibition: effects of modulatory receptor systems and excitatory amino acid antagonists. <i>Pain</i> 1989;37:111–23	401
54	Handwerker HO, Iggo A, Zimmermann M. Segmental and supraspinal actions on dorsal horn neurons responding to noxious and non-noxious skin stimuli. <i>Pain</i> 1975;1:147–65	394
55	Wall PD, Devor M. Sensory afferent impulses originate from dorsal root ganglia as well as from the periphery in normal and nerve injured rats. <i>Pain</i> 1983;17:321–39	391
56	Jensen MP, Turner JA, Romano JM, et al. Coping with chronic pain: a critical review of the literature. <i>Pain</i> 1991;47:249–83	390
57	Sullivan MJ, Thorn B, Haythornthwaite JA, et al. Theoretical perspectives on the relation between catastrophizing and pain. <i>Clin J Pain</i> 2001;17:52–64	389
58	Treede RD, Kenshalo DR, Gracely RH, et al. The cortical representation of pain. <i>Pain</i> 1999;79:105–11	387
59	Ness TJ, Gebhart GF. Visceral pain: a review of experimental studies. <i>Pain</i> 1990;41:167–234	382
59	Kehlet H, Dahl JB. The value of “multimodal” or “balanced analgesia” in postoperative pain treatment. <i>Anesth Analg</i> 1993;77:1048–56	382
61	Wall PD, Devor M, Inbal R, et al. Autotomy following peripheral nerve lesions: experimental anaesthesia dolorosa. <i>Pain</i> 1979;7:103–11	379

**Table 2** continued

Rank	Article	No. of citations
61	Collins SL, Moore RA, McQuay HJ. The visual analogue pain intensity scale: what is moderate pain in millimetres? <i>Pain</i> 1997;72:95–7	379
63	Bromage PR, Camporesi E, Chestnut D. Epidural narcotics for postoperative analgesia. <i>Anesth Analg</i> 1980;59:473–80	376
64	Apkarian AV, Bushnell MC, Treede RD, et al. Human brain mechanisms of pain perception and regulation in health and disease. <i>Eur J Pain</i> 2005;9:463–84	375
65	Price DD, Dubner R. Neurons that subserve the sensory-discriminative aspects of pain. <i>Pain</i> 1977;3:307–38	373
66	Messing RB, Lytle LD. Serotonin-containing neurons: their possible role in pain and analgesia. <i>Pain</i> 1977;4:1–21	372
67	Attal N, Jazat F, Kayser V, et al. Further evidence for ‘pain-related’ behaviours in a model of unilateral peripheral mononeuropathy. <i>Pain</i> 1990;41:235–51	370
68	Grunau RV, Craig KD. Pain expression in neonates: facial action and cry. <i>Pain</i> 1987;28:395–410	359
68	Roberts WJ. A hypothesis on the physiological basis for causalgia and related pains. <i>Pain</i> 1986;24(3):297–311	359
70	Shibata M, Ohkubo T, Takahashi H, et al. Modified formalin test: characteristic biphasic pain response. <i>Pain</i> 1989;38:347–52	358
71	Ballantyne JC, Carr DB, de Ferranti S, et al. The comparative effects of postoperative analgesic therapies on pulmonary outcome: cumulative meta-analyses of randomized, controlled trials. <i>Anesth Analg</i> 1998;86:598–612	352
72	Willer JC. Comparative study of perceived pain and nociceptive flexion reflex in man. <i>Pain</i> 1977;3:69–80	350
73	Ohnhaus EE, Adler R. Methodological problems in the measurement of pain: a comparison between the verbal rating scale and the visual analogue scale. <i>Pain</i> 1975;1:379–84	349
73	Zech DF, Grond S, Lynch J, et al. Validation of World Health Organization Guidelines for cancer pain relief: a 10-year prospective study. <i>Pain</i> 1995;63:65–76	349
75	Riley JL, Robinson ME, Wise EA, et al. Sex differences in the perception of noxious experimental stimuli: a meta-analysis. <i>Pain</i> 1998;74:181–7	347
76	Portenoy RK, Foley KM. Chronic use of opioid analgesics in non-malignant pain: report of 38 cases. <i>Pain</i> 1986;25:171–86	345
76	American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. <i>Anesthesiology</i> 2002;96:1004–17	345
78	Wall PD. The prevention of postoperative pain. <i>Pain</i> 1988;33:289–90	343
79	Decosterd I, Woolf CJ. Spared nerve injury: an animal model of persistent peripheral neuropathic pain. <i>Pain</i> 2000;87:149–58	338
80	Derbyshire SW, Jones AK, Gyulai F, et al. Pain processing during three levels of noxious stimulation produces differential patterns of central activity. <i>Pain</i> 1997;73:431–45	331
80	Tuman KJ, McCarthy RJ, March RJ, et al. Effects of epidural anesthesia and analgesia on coagulation and outcome after major vascular surgery. <i>Anesth Analg</i> 1991;73:696–704	331
82	Bieri D, Reeve RA, Champion GD, et al. The Faces Pain Scale for the self-assessment of the severity of pain experienced by children: development, initial validation, and preliminary investigation for ratio scale properties. <i>Pain</i> 1990;41:139–50	329
83	Gracely RH, McGrath F, Dubner R. Ratio scales of sensory and affective verbal pain descriptors. <i>Pain</i> 1978;5:5–18	327
84	Price DD, Hu JW, Dubner R, et al. Peripheral suppression of first pain and central summation of second pain evoked by noxious heat pulses. <i>Pain</i> 1977;3:57–68	326
85	Onghena P, Van Houdenhove B. Antidepressant-induced analgesia in chronic non-malignant pain: a meta-analysis of 39 placebo-controlled studies. <i>Pain</i> 1992;49:205–19	325
86	Price DD, Bush FM, Long S, et al. A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. <i>Pain</i> 1994;56:217–26	324
87	Crook J, Rideout E, Browne G. The prevalence of pain complaints in a general population. <i>Pain</i> 1984;18:299–314	323
88	Tverskoy M, Cozacov C, Ayache M, et al. Postoperative pain after inguinal herniorrhaphy with different types of anesthesia. <i>Anesth Analg</i> 1990;70:29–35	319
88	Hsieh JC, Belfrage M, Stone-Elander S, et al. Central representation of chronic ongoing neuropathic pain studied by positron emission tomography. <i>Pain</i> 1995;63:225–36	319
90	Ren K, Hylden JL, Williams GM, et al. The effects of a non-competitive NMDA receptor antagonist, MK-801, on behavioral hyperalgesia and dorsal horn neuronal activity in rats with unilateral inflammation. <i>Pain</i> 1992;50:331–44	316
90	Keefe FJ, Brown GK, Wallston KA, et al. Coping with rheumatoid arthritis pain: catastrophizing as a maladaptive strategy. <i>Pain</i> 1989;37:51–6	316

**Table 2** continued

Rank	Article	No. of citations
92	Stein C. Peripheral mechanisms of opioid analgesia. <i>Anesth Analg</i> 1993;76:182–91	314
93	Campbell JN, Raja SN, Meyer RA, et al. Myelinated afferents signal the hyperalgesia associated with nerve injury. <i>Pain</i> 1988;32:89–94	313
94	Simone DA, Baumann TK, LaMotte RH. Dose-dependent pain and mechanical hyperalgesia in humans after intradermal injection of capsaicin. <i>Pain</i> 1989;38:99–107	311
95	Ward SE, Goldberg N, Miller-McCauley V, et al. Patient-related barriers to management of cancer pain. <i>Pain</i> 1993;52:319–24	310
95	Capdevila X, Barthelet Y, Biboulet P, et al. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. <i>Anesthesiology</i> 1999;91:8–15	310
97	Hylden JL, Nahin RL, Traub RJ, et al. Expansion of receptive fields of spinal lamina I projection neurons in rats with unilateral adjuvant-induced inflammation: the contribution of dorsal horn mechanisms. <i>Pain</i> 1989;37:229–43	308
98	Kingery WS. A critical review of controlled clinical trials for peripheral neuropathic pain and complex regional pain syndromes. <i>Pain</i> 1997;73:123–39	306
99	Bach S, Noreng MF, Tjellden NU. Phantom limb pain in amputees during the first 12 months following limb amputation, after preoperative lumbar epidural blockade. <i>Pain</i> 1988;33:297–301	305
100	Devor M, Wall PD, Catalan N. Systemic lidocaine silences ectopic neuroma and DRG discharge without blocking nerve conduction. <i>Pain</i> 1992;48:261–8	302

**Table 3** Top 5 citation classics in every decade from 1970 to 2010

Period	Year	Title	Journal	No. of citations
1970–1979	1975	The McGill Pain Questionnaire: major properties and scoring methods	<i>Pain</i>	2,828
	1976	Graphic representation of pain	<i>Pain</i>	1,290
	1977	The formalin test: a quantitative study of the analgesic effects of morphine, meperidine, and brain stem stimulation in rats and cats	<i>Pain</i>	1,221
	1976	The reliability of a linear analogue for evaluating pain	<i>Pain</i>	729
	1979	Diffuse noxious inhibitory controls (DNIC). I. Effects on dorsal horn convergent neurones in the rat	<i>Pain</i>	677
1980–1989	1983	Ethical guidelines for investigations of experimental pain in conscious animals	<i>Pain</i>	3,017
	1988	A peripheral mononeuropathy in rat that produces disorders of pain sensation like those seen in man	<i>Pain</i>	2,014
	1988	A new and sensitive method for measuring thermal nociception in cutaneous hyperalgesia	<i>Pain</i>	1,958
	1987	The short-form McGill Pain Questionnaire	<i>Pain</i>	1,219
	1983	The use of coping strategies in chronic low back pain patients: relationship to patient characteristics and current adjustment	<i>Pain</i>	992
1990–1999	1992	An experimental model for peripheral neuropathy produced by segmental spinal nerve ligation in the rat	<i>Pain</i>	1,396
	1993	Contribution of central neuroplasticity to pathological pain: review of clinical and experimental evidence	<i>Pain</i>	1,210
	1991	The induction and maintenance of central sensitization is dependent on <i>N</i> -methyl-D-aspartic acid receptor activation; implications for the treatment of post-injury pain hypersensitivity states.	<i>Pain</i>	1,085
	1990	A novel behavioral model of neuropathic pain disorders produced in rats by partial sciatic nerve injury	<i>Pain</i>	819
	1992	The formalin test: an evaluation of the method	<i>Pain</i>	765
2000–2010	2000	Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art	<i>Pain</i>	728
	2001	Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale	<i>Pain</i>	720
	2001	Theoretical perspectives on the relation between catastrophizing and pain	<i>Clin J Pain</i>	389
	2005	Human brain mechanisms of pain perception and regulation in health and disease	<i>Eur J Pain</i>	375
	2002	Practice guidelines for sedation and analgesia by non-anesthesiologists	<i>Anesthesiology</i>	345

**Table 4** Journals in which the top 100 cited articles were published

Rank	Journals	No. of articles	Impact factor (2009)
1	<i>Pain</i>	84	5.371
2	<i>Anesthesia &amp; Analgesia</i>	7	3.083
3	<i>Anesthesiology</i>	6	5.354
4	<i>European Journal of Pain</i>	1	3.371
4	<i>Clinical Journal of Pain</i>	1	3.005
4	<i>Anaesthesia</i>	1	2.855

**Table 5** Countries of origin of the top 100 cited articles

Rank	Countries	No. of articles
1	USA	47
2	United Kingdom	12
3	Canada	10
4	Germany	7
5	France	5
6	Netherlands	3
6	Israel	3
6	Sweden	3
6	Denmark	3
10	Norway	2
10	Belgium	2
12	Japan	1
12	Switzerland	1
12	Australia	1

Although it is impossible to carry out a detailed analysis of all the 100 highly-cited articles, some observations could be found about the top 10. These 10 classic citations reflected major advances in pain research and a number of hot topics during the 40 years. The leading article by Zimmermann described the ethical guidelines for the research of experimental pain in conscious animals in 1983 and represented its cornerstone contribution in pain research. Two of the top 10 articles introduced the McGill Pain Questionnaire in 1975 and the short-form McGill Pain Questionnaire in 1987, suggesting its monumental status in pain research. At positions 3 and 5, two experimental animal models for peripheral neuropathic pain were reported. At position 4, Hargreaves and colleagues described a new method for evaluating thermal nociception in cutaneous hyperalgesia. Other major advances in pain research are represented by the graphic representation of pain by Scott and Huskisson in 1976; the formalin test, a quantitative test of the analgesic effects by Dubuisson and Dennis in 1977; contribution of central neuroplasticity to pathological pain byCoderre and coworkers in 1993; and

**Table 6** Institutions of origin with two or more top-cited articles

Rank	Institutions	No. of articles
1	National Institutes of Health (USA)	8
2	University College London	6
3	McGill University	4
4	Mayo Clinic	3
4	Institut National de la Sante et de la Recherche Medicale	3
4	University of Wisconsin	3
4	Medical College of Virginia	3
8	Duke University Medical Center	2
8	Hebrew University of Jerusalem	2
8	University of Bergen	2
8	University of Oxford	2
8	University of Iowa	2
8	Dalhousie University	2
8	Karolinska Hospital	2
8	Massachusetts General Hospital	2
8	University of Washington	2
8	Memorial Sloan-Kettering Cancer Center	2

**Table 7** Most frequent authors of the top 100 cited articles

Author	Corresponding	First	Second	Total
Price DD	1	3	2	6
Wall PD	3	–	1	4
Devor M	1	–	2	3
Dickenson AH	1	–	2	3
Dubner R	–	–	3	3
Melzack R	2	1	–	3
Vlaeyen JW	2	–	1	3
Woolf CJ	3	–	–	3
Yaksh TL	2	1	–	3
Keefe FJ	1	–	1	2
Le Bars D	2	–	–	2
Portenoy RK	1	1	–	2
Foley KM	1	–	1	2
Gebhart GF	1	–	1	2
Gracely RH	2	–	–	2
Hyliden JL	1	–	1	2
Jensen MP	1	1	–	2
McQuay HJ	2	–	–	2

*N*-methyl-D-aspartic acid receptor activation in the induction and maintenance of central sensitization by Woolf and Thompson in 1991.

In addition, we also summarized the top 5 classic papers in every decade from 1970 to 2010 (Table 3); 17 of the selected citation classics were published in *Pain*. In 1970–1979,

**Table 8** Study design of the top 100 cited articles

Study design	No. of articles
Observational study	39
Review article	25
Basic science	20
Systematic review	7
Randomized controlled trial	6
Guideline	2
Editorial	1

research on evaluating pain in both clinical and basic science was the hottest topic, including the McGill Pain Questionnaire, graphic representation of pain, formalin test, etc. In 1980–1989, the hot topics were diffused, including the ethical guideline of experimental pain in conscious animals, an experimental animal model of peripheral mononeuropathy, a method for measuring thermal nociception in behavioral hyperalgesia, the short-form McGill Pain Questionnaire, and coping strategies in chronic low back pain. In 1990–1999, the hottest topics included the experimental models for peripheral neuropathy and neuropathic pain disorders, central neuroplasticity in pathological pain, *N*-methyl-D-aspartic acid receptor activation in central sensitization, and the formalin test. Finally, in 2000–2010, the hottest topics were fear-avoidance in chronic musculoskeletal pain, the 11-point numerical chronic pain rating scale, the relationship between catastrophizing and pain, human brain mechanisms of pain perception and regulation, and practical guidelines for sedation and analgesia for non-anesthesiologists.

The finding that the top most-cited articles came from the United States was anticipated and is consistent with the origins of the top 100 citation classics in the fields of anesthesia [2] and critical care medicine [3]. Also, 9 of the 17 top productive institutions lie in the USA. These findings confirm the USA's overwhelming impact on medical science research because of its large population and the abundant financial resources available to the scientific community. It is also reported that American authors tend to be biased in their citation process toward local articles [9] and that U.S. reviewers prefer U.S. papers [10].

Another observation is not surprising. The list of the most frequent authors of pain research citation classics gave a sample of some of the best recognized scientists in pain research; however, not all famous scientists in pain research were mentioned, which is consistent with a previous study on anesthesia [2]. Journal editors may consider inviting these researchers to publish subsequent manuscripts or to write reviews. In many cross-discipline studies of frequently cited articles, methodological articles and reviews usually predominate [8, 11]. In this study, although original research only accounted for 65% of all citation

classics, there were four observational studies and four basic science studies in the top-ten articles. It was noteworthy that 7 of the 100 citation classics were systematic reviews, which were all published after 1990, suggesting the close attention to meta-analysis in recent years.

Most of the citation classic articles are still regularly cited now. Time can have much effect on an article's citation ranking, because the citations of an article logically depend on its publication time, and citations accumulate over time. Therefore, the group of the most cited articles could be dominated by some of the earliest ones [6]. Scientific articles are usually not cited until 1 or 2 years after the publication and generally reach a peak after 3–10 years [12]. Conversely, as time passes, even classic papers may gradually be less often cited because their findings have been absorbed into current knowledge without further need for citing earlier references [11].

There were 84 classic articles published in *Pain*, documenting *Pain* as the leading journal in the specialty of pain research. *Pain* not only has the highest impact factor of 5.37 in the category of anesthesiology and the specialty of pain research in 2009, but also has the most total citations in 2009 (25,665), demonstrating *Pain*'s high impact.

There were some limitations in this analysis. First, the major limitation was that this study restricted literature survey in pain research and anesthetic journals and did not cover the whole field of pain research; therefore, some classic citations in pain research in other subjects, such as neurology, oncology, trauma, etc., were not included. Second, some important articles in the field of basic pain research were published in other famous journals, such as *Nature*, *Science*, *Cell*, etc., which were not included for analysis in this study. This study limited the literature search in the specialized pain journals and the anesthesiology journals. However, this study showed some major articles in the field of pain research.

In conclusion, these top-cited articles in pain research identify topics, authors, and institutions that contributed to major advances in the specialty of pain research. This analysis of the top citation classics allows for the recognition of major advances in pain research and supplies a historic perspective on the progress of pain research.

**Conflict of interest** none.

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