

Citation analysis of the most influential publications on whiplash injury

A STROBE-compliant study

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Abstract

Whiplash injury is a common diagnosis and causes substantial economic burden. Numerous papers have been published to provide new insights into whiplash injury. However, so far there has not been a comprehensive analysis of the most influential publications on whiplash injury. This study aimed to determine the 100 most cited publications on whiplash injury and analyze their characteristics. A keyword search was conducted using the Web of Science database. The top 100 cited publications relevant to whiplash injury were gathered. The main characteristics including title, year of publication, citation, authorship, journal, country, institution, and topic were generated. The number of citations of the top 100 cited publications ranged from 82 to 777. Fifteen countries contributed the top 100 publications. Australia had the largest number of publications (26), followed by the United States (21), and Canada (12). The majority of the publications were from Europe (40) and North America (33). A total of 19 institutions and 17 authors published more than one publication. The University of Queensland (16) and the author Sterling M (7) had the leading publication record. This is the first citation analysis to identify and characterize the highest impact researches on whiplash injury. The present analysis provides the most influential studies on whiplash injury, and reveals the leading journals, countries, institutions, and authors with special contributions in this field. The list may serve as an archive of historical development of whiplash injury and a basis for further research.

Abbreviation: NEJM = The New England Journal of Medicine.

Keywords: citation analysis, publication, Whiplash injury

1. Introduction

Whiplash injury is a common trauma caused by rapid acceleration–deceleration movements of the head and neck.^[1,2] The annual incidence of whiplash injury is estimated to be 328 to 677 per 100,000 inhabitants.^[1–3] It most commonly occurs in road traffic accidents, involving more than 80% of persons in motor vehicles collision.^[1] Whiplash-associated disorders are used to describe neck pain and clusters of physical and psychological symptoms experienced after a whiplash injury.^[4] Approximately 50% of individuals suffer from persistent pain 1 year after whiplash injury, and as many as 25% of them develop a long-term complex pain related disability.^[2,5,6] Whiplash injury represents an important and growing burden.^[4,6–8] The annual economic cost of whiplash injury is estimated to be \$3.9 billion in the United States.^[6,7]

A large number of papers on whiplash injury have been published in the journals to share new knowledge in this field.^[2–4,6–8] Among the numerous papers, some important publications may play a vital role in the progress of whiplash injury research.^[2,4,8] However, there is a lack of studies to identify these most influential publications in the field of whiplash injury.

The number of citations is an important indicator for the academic impact of the publications.^[9] Citation analysis has been widely performed in multiple disciplines to quantitatively and qualitatively analyze important information of certain topic.^[10–27] Citation analysis of the most influential publications have been carried out in many filed.^[10–27] However, there have been few studies regarding the most cited publications on whiplash injury. The purpose of the present study was to determine the 100 most cited publications on whiplash injury and analyze their characteristics.

2. Methods

Ethical approval was not required because this work did not contain any studies with patients or animals. The Web of Science database was used for this citation analysis.^[10–27] The keywords included “whiplash,” “whiplash injury,” whiplash injuries,” “whiplash-associated disorder,” and “whiplash-associated disorders.”^[4,8] The literature search was carried out on January 6th, 2022. No limitation was used in the publication time or article type. The searching results ranked by the citation count of the publications. Two authors independently

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Table 1**The 100 most cited publications on whiplash injury.**

| Rank | Author (first) | Yr | Article | Journal | Citation number | Citation density |
|------|---------------------|------|---|--------------------------------------|-----------------|------------------|
| 1 | Spitzer WO | 1995 | Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining “whiplash” and its management | <i>Spine</i> | 777 | 31.08 |
| 2 | Cassidy JD | 2000 | Effect of eliminating compensation for pain and suffering on the outcome of insurance claims for whiplash injury | <i>NEJM</i> | 445 | 22.25 |
| 3 | Caffey J | 1974 | The whiplash shaken infant syndrome: manual shaking by the extremities with whiplash-induced intracranial and intraocular bleedings, linked with residual permanent brain damage and mental retardation | <i>Pediatrics</i> | 412 | 8.96 |
| 4 | Lord SM | 1996 | Percutaneous radio-frequency neurotomy for chronic cervical zygapophyseal-joint pain | <i>NEJM</i> | 408 | 17.00 |
| 5 | Barnsley L | 1994 | Whiplash injury | <i>Pain</i> | 325 | 12.50 |
| 6 | Sterling M | 2003 | Sensory hypersensitivity occurs soon after whiplash injury and is associated with poor recovery | <i>Pain</i> | 315 | 18.53 |
| 7 | Lord SM | 1996 | Chronic cervical zygapophysial joint pain after whiplash. A placebo-controlled prevalence study | <i>Spine</i> | 298 | 12.42 |
| 8 | Banic B | 2004 | Evidence for spinal cord hypersensitivity in chronic pain after whiplash injury and in fibromyalgia | <i>Pain</i> | 295 | 18.44 |
| 9 | Barnsley L | 1995 | The prevalence of chronic cervical zygapophysial joint pain after whiplash | <i>Spine</i> | 287 | 11.48 |
| 10 | Scholten-Peeters | 2003 | Prognostic factors of whiplash-associated disorders: a systematic review of prospective cohort studies | <i>Pain</i> | 287 | 16.88 |
| 11 | Schrader H | 1996 | Natural evolution of late whiplash syndrome outside the medicolegal context | <i>Lancet</i> | 270 | 11.25 |
| 12 | Carroll LJ | 2008 | Course and prognostic factors for neck pain in whiplash-associated disorders (WAD): results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders | <i>Spine</i> | 261 | 21.75 |
| 13 | Guthkelch AN | 1971 | Infantile subdural hematoma and its relationship to whiplash injuries | <i>BMJ</i> | 245 | 5.00 |
| 14 | Radanov BP | 1995 | Long-term outcome after whiplash injury. A 2-year follow-up considering features of injury mechanism and somatic, radiologic, and psychosocial findings | <i>Medicine</i> | 243 | 9.72 |
| 15 | Jull G | 2004 | Impairment in the cervical flexors: a comparison of whiplash and insidious onset neck pain patients | <i>Man Ther</i> | 239 | 14.94 |
| 16 | Treleaven J | 2003 | Dizziness and unsteadiness following whiplash injury: characteristic features and relationship with cervical joint position error | <i>J Rehabil Med</i> | 227 | 13.35 |
| 17 | Sterling M | 2005 | Physical and psychological factors predict outcome following whiplash injury | <i>Pain</i> | 226 | 15.07 |
| 18 | Curatolo M | 2001 | Central hypersensitivity in chronic pain after whiplash injury | <i>Clin J Pain</i> | 214 | 11.26 |
| 19 | Obelieniene D | 1999 | Pain after whiplash: a prospective controlled inception cohort study | <i>J Neurol Neurosurg Psychiatry</i> | 208 | 9.90 |
| 20 | Sterling M | 2003 | Development of motor system dysfunction following whiplash injury | <i>Pain</i> | 197 | 11.59 |
| 21 | Ommaya AK | 1968 | Whiplash injury and brain damage: an experimental study | <i>JAMA</i> | 184 | 3.54 |
| 22 | Scott D | 2005 | Widespread sensory hypersensitivity is a feature of chronic whiplash-associated disorder but not chronic idiopathic neck pain | <i>Clin J Pain</i> | 178 | 11.87 |
| 23 | Sterling M | 2006 | Physical and psychological factors maintain long-term predictive capacity post-whiplash injury | <i>Pain</i> | 177 | 12.64 |
| 24 | Kamper SJ | 2008 | Course and prognostic factors of whiplash: a systematic review and meta-analysis | <i>Pain</i> | 176 | 14.67 |
| 25 | Hadley MN | 1989 | The infant whiplash-shake injury syndrome: a clinical and pathological study | <i>Neurosurgery</i> | 174 | 5.61 |
| 26 | Gonzalez-Iglesias J | 2009 | Short-term effects of cervical kinesio taping on pain and cervical range of motion in patients with acute whiplash injury: a randomized clinical trial | <i>J Orthop Sports Phys Ther</i> | 168 | 15.27 |
| 27 | Koelbaek Johansen M | 1999 | Generalised muscular hyperalgesia in chronic whiplash syndrome | <i>Pain</i> | 166 | 7.90 |
| 28 | McLean SA | 2005 | The development of persistent pain and psychological morbidity after motor vehicle collision: integrating the potential role of stress response systems into a biopsychosocial model | <i>Psychosom Med</i> | 165 | 11.00 |
| 29 | Ommaya AK | 1971 | Tolerances for cerebral concussion from head impact and whiplash in primates | <i>J Biomech</i> | 162 | 3.31 |
| 30 | Dall'Alba PT | 2001 | Cervical range of motion discriminates between asymptomatic persons and those with whiplash | <i>Spine</i> | 161 | 8.47 |
| 31 | Radanov BP | 1991 | Role of psychosocial stress in recovery from common whiplash [see comment] | <i>Lancet</i> | 158 | 5.45 |
| 32 | Sullivan MJ | 2006 | A psychosocial risk factor--targeted intervention for the prevention of chronic pain and disability following whiplash injury | <i>Phys Ther</i> | 155 | 11.07 |
| 33 | Lord SM | 1995 | The utility of comparative local anesthetic blocks versus placebo-controlled blocks for the diagnosis of cervical zygapophysial joint pain | <i>Clin J Pain</i> | 152 | 6.08 |
| 34 | Holm LW | 2008 | The burden and determinants of neck pain in whiplash-associated disorders after traffic collisions: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders | <i>Spine</i> | 152 | 12.67 |
| 35 | Kaneoka K | 1999 | Motion analysis of cervical vertebrae during whiplash loading | <i>Spine</i> | 150 | 7.14 |
| 36 | Jull G | 2007 | Does the presence of sensory hypersensitivity influence outcomes of physical rehabilitation for chronic whiplash?--A preliminary RCT | <i>Pain</i> | 144 | 11.08 |

(Continued)

Table 1
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| Rank | Author (first) | Yr | Article | Journal | Citation number | Citation density |
|------|-------------------|------|---|--------------------------------------|-----------------|------------------|
| 37 | Heikkilä H | 1998 | Cervicocephalic kinesthetic sensibility, active range of cervical motion, and oculomotor function in patients with whiplash injury | <i>Arch Phys Med Rehabil</i> | 144 | 6.55 |
| 38 | Nederhand MJ | 2004 | Predictive value of fear avoidance in developing chronic neck pain disability: consequences for clinical decision making | <i>Arch Phys Med Rehabil</i> | 142 | 8.88 |
| 39 | Gay JR | 1953 | Common whiplash injuries of the neck | <i>JAMA</i> | 140 | 2.09 |
| 40 | Borchgrevink GE | 1998 | Acute treatment of whiplash neck sprain injuries. A randomized trial of treatment during the first 14 days after a car accident | <i>Spine</i> | 140 | 6.36 |
| 41 | Davis SJ | 1991 | Cervical spine hyperextension injuries: MR findings | <i>Radiology</i> | 139 | 4.79 |
| 42 | Mealy K | 1986 | Early mobilization of acute whiplash injuries | <i>BMJ</i> | 138 | 4.06 |
| 43 | Loudon JK | 1997 | Ability to reproduce head position after whiplash injury | <i>Spine</i> | 138 | 6.00 |
| 44 | Elliott J | 2006 | Fatty infiltration in the cervical extensor muscles in persistent whiplash-associated disorders: a magnetic resonance imaging analysis | <i>Spine</i> | 137 | 9.79 |
| 45 | Grauer JN | 1997 | Whiplash produces an S-shaped curvature of the neck with hyperextension at lower levels | <i>Spine</i> | 136 | 5.91 |
| 46 | Sterling M | 2003 | The development of psychological changes following whiplash injury | <i>Pain</i> | 135 | 7.94 |
| 47 | Pearson AM | 2004 | Facet joint kinematics and injury mechanisms during simulated whiplash | <i>Spine</i> | 132 | 8.25 |
| 48 | Barnsley L | 1994 | Lack of effect of intraarticular corticosteroids for chronic pain in the cervical zygapophyseal joints | <i>NEJM</i> | 130 | 5.00 |
| 49 | Jull G | 2000 | Deep Cervical Flexor Muscle Dysfunction in Whiplash | <i>J Musculoskelet Pain</i> | 127 | 6.35 |
| 50 | Wallis BJ | 1997 | Resolution of psychological distress of whiplash patients following treatment by radiofrequency neurotomy: a randomized, double-blind, placebo-controlled trial | <i>Pain</i> | 126 | 5.48 |
| 51 | Winkelstein BA | 2000 | The cervical facet capsule and its role in whiplash injury: a biomechanical investigation | <i>Spine</i> | 122 | 6.10 |
| 52 | Nederhand MJ | 2000 | Cervical muscle dysfunction in the chronic whiplash associated disorder grade II (WAD-II) | <i>Spine</i> | 114 | 5.70 |
| 53 | Kasch H | 2005 | Reduced cold pressor pain tolerance in non-recovered whiplash patients: a 1-year prospective study | <i>Eur J Pain</i> | 112 | 7.47 |
| 54 | Heikkilä H | 1996 | Cervicocephalic kinesthetic sensibility in patients with whiplash injury | <i>Scand J Rehabil Med</i> | 112 | 4.67 |
| 55 | Hoving JL | 2003 | Validity of the neck disability index, Northwick Park neck pain questionnaire, and problem elicitation technique for measuring disability associated with whiplash-associated disorders | <i>Pain</i> | 110 | 6.47 |
| 56 | Hendriks EJ | 2005 | Prognostic factors for poor recovery in acute whiplash patients | <i>Pain</i> | 110 | 7.33 |
| 57 | Radanov BP | 1994 | Relationship between early somatic, radiological, cognitive and psychosocial findings and outcome during a 1-year follow-up in 117 patients suffering from common whiplash | <i>Br J Rheumatol</i> | 109 | 4.19 |
| 58 | Schmand B | 1998 | Cognitive complaints in patients after whiplash injury: the impact of malingering | <i>J Neurol Neurosurg Psychiatry</i> | 108 | 4.91 |
| 59 | Sturzenegger M | 1994 | Presenting symptoms and signs after whiplash injury: the influence of accident mechanisms | <i>Neurology</i> | 107 | 4.12 |
| 60 | Maimaris C | 1988 | "Whiplash injuries" of the neck: a retrospective study | <i>Injury</i> | 106 | 3.31 |
| 61 | Evans RW | 1992 | Some observations on whiplash injuries | <i>Neurol Clin</i> | 106 | 3.79 |
| 62 | Ronnen HR | 1996 | Acute whiplash injury: is there a role for MR imaging?--a prospective study of 100 patients | <i>Radiology</i> | 104 | 4.33 |
| 63 | Van Oosterwijck J | 2013 | Evidence for central sensitization in chronic whiplash: a systematic literature review | <i>Eur J Pain</i> | 103 | 14.71 |
| 64 | Treleaven J | 2006 | The relationship of cervical joint position error to balance and eye movement disturbances in persistent whiplash | <i>Man Ther</i> | 103 | 7.36 |
| 65 | Sterling M | 2004 | Characterization of acute whiplash-associated disorders | <i>Spine</i> | 102 | 6.38 |
| 66 | Ettlin TM | 1992 | Cerebral symptoms after whiplash injury of the neck: a prospective clinical and neuropsychological study of whiplash injury | <i>J Neurol Neurosurg Psychiatry</i> | 102 | 3.64 |
| 67 | Stewart MJ | 2007 | Randomized controlled trial of exercise for chronic whiplash-associated disorders | <i>Pain</i> | 101 | 7.77 |
| 68 | Rosenfeld M | 2000 | Early intervention in whiplash-associated disorders: a comparison of 2 treatment protocols | <i>Spine</i> | 101 | 5.05 |
| 69 | Herren-Gerber R | 2004 | Modulation of central hypersensitivity by nociceptive input in chronic pain after whiplash injury | <i>Pain Med</i> | 101 | 6.31 |
| 70 | Gotten N | 1956 | Survey of 100 cases of whiplash injury after settlement of litigation | <i>JAMA</i> | 101 | 1.58 |
| 71 | Jonsson H Jr | 1994 | Findings and outcome in whiplash-type neck distortions | <i>Spine</i> | 99 | 3.81 |
| 72 | Passatore M | 2006 | Influence of sympathetic nervous system on sensorimotor function: whiplash associated disorders (WAD) as a model | <i>Eur J Appl Physiol</i> | 97 | 6.93 |
| 73 | Siegmund GP | 2001 | Mechanical evidence of cervical facet capsule injury during whiplash: a cadaveric study using combined shear, compression, and extension loading | <i>Spine</i> | 96 | 5.05 |
| 74 | Brault JR | 2000 | Cervical muscle response during whiplash: evidence of a lengthening muscle contraction | <i>Clin Biomech</i> | 96 | 4.80 |

(Continued)

Table 1
(Continued)

| Rank | Author (first) | Yr | Article | Journal | Citation number | Citation density |
|------|-------------------|------|--|--------------------------------------|-----------------|------------------|
| 75 | Woodhouse A | 2008 | Altered motor control patterns in whiplash and chronic neck pain | <i>BMC Musculoskelet Disord</i> | 95 | 7.92 |
| 76 | Sullivan MJ | 2009 | Pain, perceived injustice and the persistence of post-traumatic stress symptoms during the course of rehabilitation for whiplash injuries | <i>Pain</i> | 95 | 8.64 |
| 77 | Panjabi MM | 1998 | Simulation of whiplash trauma using whole cervical spine specimens | <i>Spine</i> | 95 | 4.32 |
| 78 | Holm LW | 2008 | Expectations for recovery important in the prognosis of whiplash injuries | <i>PLoS Med</i> | 95 | 7.92 |
| 79 | Cote P | 2001 | The association between neck pain intensity, physical functioning, depressive symptomatology and time-to-claim-closure after whiplash | <i>J Clin Epidemiol</i> | 95 | 5.00 |
| 80 | Walton DM | 2009 | Risk factors for persistent problems following whiplash injury: results of a systematic review and meta-analysis | <i>J Orthop Sports Phys Ther</i> | 94 | 8.55 |
| 81 | Pearce JM | 1989 | Whiplash injury: a reappraisal | <i>J Neurol Neurosurg Psychiatry</i> | 94 | 3.03 |
| 82 | Freeman MD | 1999 | A review and methodologic critique of the literature refuting whiplash syndrome | <i>Spine</i> | 92 | 4.38 |
| 83 | Van Oosterwijck J | 2011 | Pain neurophysiology education improves cognitions, pain thresholds, and movement performance in people with chronic whiplash: a pilot study | <i>J Rehabil Res Dev</i> | 91 | 10.11 |
| 84 | Kasch H | 2001 | Handicap after acute whiplash injury: a 1-year prospective study of risk factors | <i>Neurology</i> | 91 | 4.79 |
| 85 | Soderlund A | 2000 | Acute whiplash-associated disorders (WAD): the effects of early mobilization and prognostic factors in long-term symptomatology | <i>Clin Rehabil</i> | 90 | 4.50 |
| 86 | Sterling M | 2010 | Compensation claim lodgement and health outcome developmental trajectories following whiplash injury: A prospective study | <i>Pain</i> | 89 | 8.90 |
| 87 | Carroll LJ | 2006 | The role of pain coping strategies in prognosis after whiplash injury: passive coping predicts slowed recovery | <i>Pain</i> | 89 | 6.36 |
| 88 | Woltring HJ | 1994 | Instantaneous helical axis estimation from 3-D video data in neck kinematics for whiplash diagnostics | <i>J Biomech</i> | 88 | 3.38 |
| 89 | Rubin AM | 1995 | Postural stability following mild head or whiplash injuries | <i>Am J Otol</i> | 88 | 3.52 |
| 90 | Krakenes J | 2002 | MRI assessment of the alar ligaments in the late stage of whiplash injury--a study of structural abnormalities and observer agreement | <i>Neuroradiology</i> | 88 | 4.89 |
| 91 | Rosenfeld M | 2003 | Active intervention in patients with whiplash-associated disorders improves long-term prognosis: a randomized controlled clinical trial | <i>Spine</i> | 87 | 5.12 |
| 92 | Walton DM | 2013 | Risk factors for persistent problems following acute whiplash injury: update of a systematic review and meta-analysis | <i>J Orthop Sports Phys Ther</i> | 86 | 12.29 |
| 93 | Treleaven J | 2005 | Smooth pursuit neck torsion test in whiplash-associated disorders: relationship to self-reports of neck pain and disability, dizziness and anxiety | <i>J Rehabil Med</i> | 86 | 5.73 |
| 94 | Harder S | 1998 | The effect of socio-demographic and crash-related factors on the prognosis of whiplash | <i>J Clin Epidemiol</i> | 86 | 3.91 |
| 95 | Brault JR | 1998 | Clinical response of human subjects to rear-end automobile collisions | <i>Arch Phys Med Rehabil</i> | 84 | 3.82 |
| 96 | Bonnier C | 1995 | Outcome and prognosis of whiplash shaken infant syndrome; late consequences after a symptom-free interval | <i>Dev Med Child Neurol</i> | 84 | 3.36 |
| 97 | Panjabi MM | 1998 | Mechanism of whiplash injury | <i>Clin Biomech</i> | 83 | 3.77 |
| 98 | Hartling L | 2001 | Prognostic value of the Quebec Classification of Whiplash-Associated Disorders | <i>Spine</i> | 83 | 4.37 |
| 99 | Cusick JF | 2001 | Whiplash syndrome: kinematic factors influencing pain patterns | <i>Spine</i> | 83 | 4.37 |
| 100 | Mayou R | 1996 | Outcome of "whiplash" neck injury | <i>Injury</i> | 82 | 3.42 |

BMJ = British Medical Journal, JAMA = Journal of the American Medical Association, NEJM = The New England Journal of Medicine.

reviewed the publications for their relevance to whiplash injury. Disagreements were resolved by discussion. A third author was invited to make a final decision when necessary. The top 100 cited publications on whiplash injury were included in this study.

Data extractions were conducted by 2 independent authors. Disagreements between authors were resolved by consensus. The following information was extracted and analyzed: title, year of publication, citation, authorship, journal, country, institution, and topic. The study topic contained etiology, treatment, risk factors, measurement, epidemiology and general to whiplash injury. The countries were classified into high-income, middle-income and low-income countries in terms of the World Bank income criteria (www.worldbank.org).^[28] Citation density (citation count/ the number of years since the paper was published) and the average citation were also analyzed.^[19,20]

3. Results

Citation count of the top 100 cited publications ranged from 82 to 777 with a mean number of 155. The most cited paper was published in the journal *Spine* in 1995, and had the highest number of citation density (31.08). The main information of these publications was listed in Table 1. The oldest and most recent publications were published in 1953 and 2013, respectively. All publications in the top 100 list were written in English.

The number of publications per decade was summarized in Figure 1. Half (50) of the total publications were published in the 2000s, followed by the 1990s (36). The publications in the 1970s had the highest number of average citations (273.00), followed by 1960s (184.00).

Thirty-seven journals contributed the top 100 publications. These journals included the general medical journals, such as *The New England Journal of Medicine (NEJM)*, *Lancet*, *Journal*

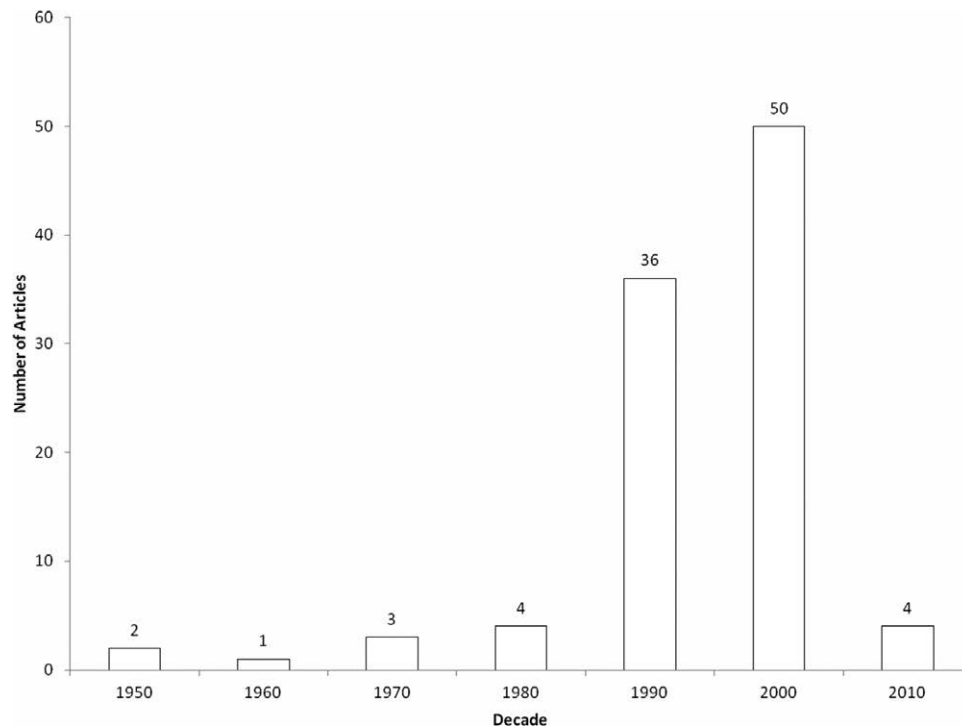


Figure 1. The number of publications per decade on whiplash injury.

of the American Medical Association, and British Medical Journal, and subspecialty spine and pain journals. There were 19 journals published more than 1 paper, which was listed in Table 2. The journal *Spine* published far more papers (23) than other journals, followed by *Pain* (18). The *NEJM* with the highest impact factor (70.670) had the highest average citation (327.67), followed by *Lancet* (214.00).

There were 15 countries producing the top 100 publications. All the countries were high-income countries. These countries were shown in Table 3. Australia was the leader according to the number of publications (26), followed by the United States (21), and Canada (12). With respect to continental distribution, the majority of the 100 publications were from Europe (40), North

America (33) and Oceania (26). Only one publication was from Asia. No publications were from South America or Africa.

A total of 53 institutions contributed the 100 publications. There were 19 institutions producing at least 2 publications. These institutions were depicted in Table 4. The University of Queensland had the leading publication record (16), followed by University of Newcastle (6). When considering the average citations, McGill University (319.33) ranked first, followed by University of Newcastle (266.67), and University of Alberta (265.00).

Some first authors were shown more than 1 time in the 100 most influential publications. These authors were summarized in Table 5. Sterling M with 7 publications was the leader in

Table 2

Journals with more than one publication on whiplash injury.

| Journal | Number of articles | Total citation | Average citation | Impact factors |
|---|--------------------|----------------|------------------|----------------|
| <i>Spine</i> | 23 | 3843 | 167.09 | 2.903 |
| <i>Pain</i> | 18 | 3163 | 175.72 | 6.029 |
| <i>Journal of Neurology Neurosurgery and Psychiatry</i> | 4 | 512 | 128.00 | 8.272 |
| <i>NEJM</i> | 3 | 983 | 327.67 | 70.670 |
| <i>Clinical Journal of Pain</i> | 3 | 544 | 181.33 | 2.893 |
| <i>JAMA</i> | 3 | 425 | 141.67 | 51.273 |
| <i>Archives of Physical Medicine and Rehabilitation</i> | 3 | 370 | 123.33 | 2.697 |
| <i>Journal of Orthopaedic & Sports Physical Therapy</i> | 3 | 348 | 116.00 | 3.058 |
| <i>Lancet</i> | 2 | 428 | 214.00 | 59.102 |
| <i>BMJ</i> | 2 | 383 | 191.50 | 27.604 |
| <i>Manual Therapy</i> | 2 | 342 | 171.00 | 2.622 |
| <i>Journal of Rehabilitation Medicine</i> | 2 | 313 | 156.50 | 1.907 |
| <i>Journal of Biomechanics</i> | 2 | 250 | 125.00 | 2.576 |
| <i>Radiology</i> | 2 | 243 | 121.50 | 7.608 |
| <i>European Journal of Pain</i> | 2 | 215 | 107.50 | 3.188 |
| <i>Neurology</i> | 2 | 198 | 99.00 | 8.689 |
| <i>Injury</i> | 2 | 188 | 94.00 | 1.834 |
| <i>Journal of Clinical Epidemiology</i> | 2 | 181 | 90.50 | 4.650 |
| <i>Clinical Biomechanics</i> | 2 | 179 | 89.50 | 1.977 |

BMJ = British Medical Journal, JAMA = Journal of the American Medical Association, NEJM = The New England Journal of Medicine.

Table 3**Countries of origin of publications on whiplash injury.**

| Country | Number of articles | Total citations | Average citations |
|----------------|--------------------|-----------------|-------------------|
| Australia | 26 | 4756 | 182.92 |
| United States | 21 | 2820 | 134.29 |
| Canada | 12 | 2362 | 196.83 |
| Switzerland | 8 | 1329 | 166.13 |
| Sweden | 8 | 880 | 110.00 |
| Netherlands | 6 | 865 | 144.17 |
| Norway | 4 | 593 | 148.25 |
| United Kingdom | 4 | 527 | 131.75 |
| Denmark | 3 | 369 | 123.00 |
| Belgium | 3 | 278 | 92.67 |
| Lithuania | 1 | 208 | 208.00 |
| Spain | 1 | 168 | 168.00 |
| Japan | 1 | 150 | 150.00 |
| Ireland | 1 | 138 | 138.00 |
| Italy | 1 | 97 | 97.00 |

Table 5**Authors with more than one publication on whiplash injury.**

| Author (First) | Number of articles | Total citations | Average citations |
|-------------------|--------------------|-----------------|-------------------|
| Sterling M | 7 | 1241 | 177.29 |
| Lord SM | 3 | 858 | 286.00 |
| Barnsley L | 3 | 742 | 247.33 |
| Jull G | 3 | 510 | 170.00 |
| Radanov BP | 3 | 510 | 170.00 |
| Treleaven J | 3 | 416 | 138.67 |
| Carroll LJ | 2 | 350 | 175.00 |
| Ommaya AK | 2 | 346 | 173.00 |
| Heikkilä H | 2 | 256 | 128.00 |
| Nederhand MJ | 2 | 256 | 128.00 |
| Sullivan MJ | 2 | 250 | 125.00 |
| Holm LW | 2 | 247 | 123.50 |
| Kasch H | 2 | 203 | 101.50 |
| Van Oosterwijck J | 2 | 194 | 97.00 |
| Brault JR | 2 | 180 | 90.00 |
| Walton DM | 2 | 180 | 90.00 |
| Panjabi MM | 2 | 178 | 89.00 |

the list. When ranked by average citations, Lord SM (268.00) topped the list, followed by Barnsley L (247.33), and Sterling M (177.29).

With respect to the topics, there were 27 publications centered on the treatment of whiplash injury, followed by etiology with 24 publications, and risk factors with 21 publications (Fig. 2).

4. Discussion

Whiplash injury is a commonly diagnosed trauma, which causes pain, functional limitations, and even prolonged disability with considerable economic burden.^[1,4,7,8] The present study, determining and characterizing the top 100 cited publications on whiplash injury, aimed to give a general insight into the most influential publications, and to help future studies in this field. Such analysis had been performed in a large number of fields.^[10–27] To our knowledge, the current study is the first citation analysis on the top 100 cited publications in the field of whiplash injury.

The citation count of the top 100 influential publications may be different in different specialties.^[11,12,14,16,19,20,23,24] The number of citations of the 100 most cited publications on diabetes ranged from 1121 to 10292, and that on Parkinson's disease ranged from 669 to 6902.^[11,12] The difference of the citation count may be attributed to multiple factors such as the number

Table 4**Institutions with more than one publication on whiplash injury.**

| Institution | Number of articles | Total citations | Average citations |
|---|--------------------|-----------------|-------------------|
| The University of Queensland | 16 | 2643 | 165.19 |
| University of Newcastle | 6 | 1600 | 266.67 |
| University of Berne | 4 | 617 | 154.25 |
| Yale University School of Medicine | 4 | 446 | 111.50 |
| McGill University | 3 | 958 | 319.33 |
| University of Alberta | 3 | 795 | 265.00 |
| University Hospital of Bern | 3 | 610 | 203.33 |
| University Hospital Trondheim | 2 | 410 | 205.00 |
| National Institutes of Health | 2 | 346 | 173.00 |
| Hull Royal Infirmary | 2 | 339 | 169.50 |
| University of Sydney | 2 | 277 | 138.50 |
| Roessingh, Research and Development | 2 | 256 | 128.00 |
| University Hospital of Northern Sweden | 2 | 256 | 128.00 |
| Karolinska Institutet | 2 | 247 | 123.50 |
| Aarhus University | 2 | 203 | 101.50 |
| Vrije Universiteit Brussel | 2 | 194 | 97.00 |
| University of Gothenburg | 2 | 188 | 94.00 |
| Biomechanics Research & Consulting, Inc | 2 | 180 | 90.00 |
| Western University | 2 | 180 | 90.00 |

of researchers and the size of total publications in specific field.^[14,16,19,20,23,24]

It is believed that old papers had advantages in receiving more citations due to the long time after publication.^[11,12,14,17,20,24] This was proved in many citation analyses.^[10–27] The publication production on surgery by decade reached a peak in the 1970s.^[25] The 1980s contributed the most publications in burns and knee research.^[17,24] The largest number of the top 100 cited publications on imaging and spine were both published in the 1990s.^[22,26] However, the present study demonstrated that the 2000s was the most prolific decade. The increasing number of publications and the progress of quality of publications may be important reasons for this finding.^[17,19–21,26] Another explanation may be that the Quebec Task Force redefined the whiplash and its management in 1995, which may promote the development of whiplash injury research.^[4]

All the top 100 papers published in English, which may prove that English was the most influential language in academic community. The journal *Spine* produced the majority of publications, followed by *pain*. This demonstrated that these journals have the greatest impact in the field of whiplash injury.^[11,19,20,24–26] There may be some reasons for this finding. First, the researchers have a tendency to submit their important work to these subspecialty journals.^[18–20,26] Second, the authors tend to cite publications from main journals in their specialty.^[20,26] In addition, we found that 4 leading general medicine journals, including *NEJM*, *Lancet*, *Journal of the American Medical Association*, and *British Medical Journal*, produced at least 2 most influential publications on whiplash injury. This indicates some papers on whiplash injury are of high quality, and could be accepted in the highest impact general journals.^[11,18,19]

A total of 15 countries produced the top 100 publications, which might suggest that the most influential publications still centered in a few countries.^[20,22,23,26] These countries were classified into high-income countries. It may indicate that the economic situation of the countries plays a vital role in conducting the high impact work.^[19,20,26,28] In addition, we found that no publications were from South America and Africa. This result may reflect that the quality of papers from these areas is still lag behind that from the other regions.^[20,28]

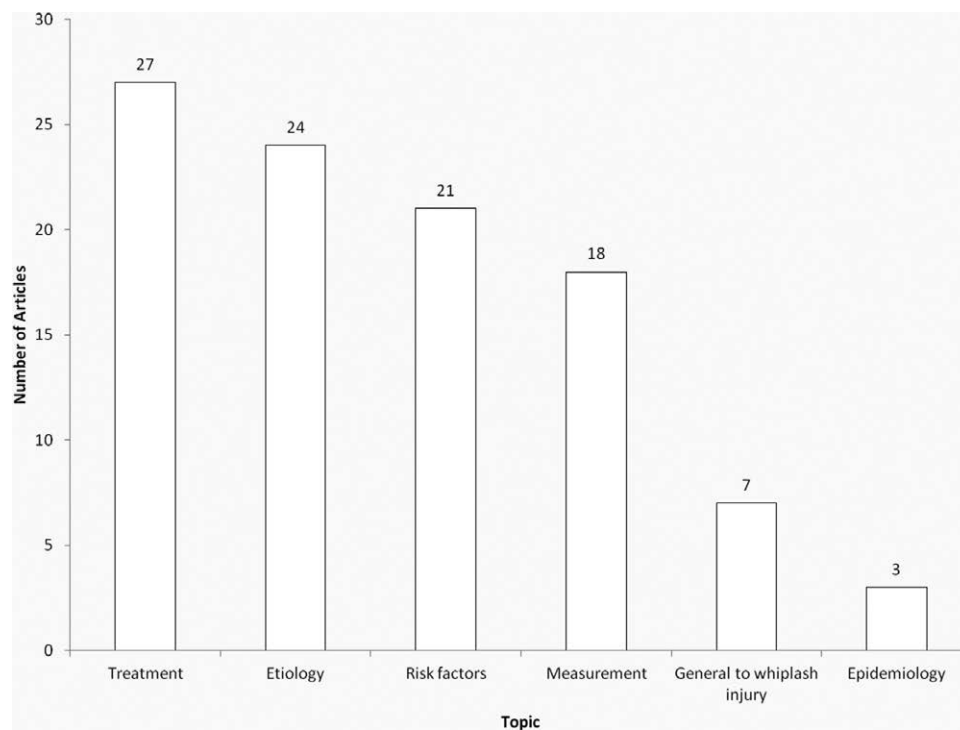


Figure 2. Topics of the 100 most cited publications on whiplash injury.

It is very interesting to find that Australia was the most prolific countries on whiplash injury, and the United States ranked second. The greatest power of the United States has been proved in nearly all the medical fields.^[10-27] The United States always ranks first in terms of the research contributions. It may be because that the United States has the great advantages in the investigators and financial supports.^[18-20,26] However, this phenomenon was not found in the field of whiplash injury. This may suggest that the some institutions and researchers in Australia are very interested in whiplash injury, and have a great priority in this field.^[18-20] This study also proves this factor. We found that the Australian institutions and authors have outstanding publication record especially The University of Queensland and Sterling M, which published far more papers than other institutions and authors.

The current study had some limitations, which had been demonstrated in pervious citation analysis.^[10-27] First, there were no golden indicators for assessing the impact of publications despite the number of citations were widely used in citation analysis. The influential papers with low citations may not be included in this study. Second, the recent papers had a tendency to receive lower citations, and the old publications may have an accumulated effect in the citation count. The influential publications published in recent years may not be included. Third, the effect of self-citation on the number of citations could not be eliminated in this study, which may increase the citation count. Fourth, the Web of Science database was use as the literature source. The citation count of publications may be different in other database when conducting citation analysis on the same topic.

5. Conclusion

This is the first citation analysis to identify and characterize the highest impact researches on whiplash injury. The present study provides the 100 most cited publications, and summarizes the impact journals, counties, institutions, authors with leading publication records. The list may be functioned as an archive of the influential studies on whiplash injury, and a basis for further research in this field.

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