Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Critical Care (2010) **25**, 157–170

ELSEVIER

Journal of Critical Care

A View of the Literature

The most influential articles in critical care medicine☆

Andrew L. Rosenberg MD*, Ravi S. Tripathi MD, James Blum MD

Department of Anesthesiology, University of Michigan Medical School, Ann Arbor, MI 48109-5861, USA

Keywords:
Critical care;
ICU;
Citation classics;
Landmark articles

Abstract

Purpose: The study aimed to examine query strategies that would provide an exhaustive search method to retrieve the most referenced articles within specific categories of critical care.

Material and Methods: A comprehensive list of the most cited critical care medicine articles was generated by searching the Science Citation Index Expanded data set using general critical care terms keywords such as "critical care," critical care journal titles, and keywords for subsubjects of critical care.

Results: The final database included 1187 articles published between 1905 and 2006. The most cited article was referenced 4909 times. The most productive search term was *intensive care*. However, this term only retrieved 25% of the top 100 articles. Furthermore, 662 of the top 1000 articles could not be found using any of the basic critical care search terms. Sepsis, acute lung injury, and mechanical ventilation were the most common areas of focus for the articles retrieved.

Conclusion: Retrieving frequently cited, influential articles in critical care requires using multiple search terms and manuscript sources. Periodic compilations of most cited articles may be useful for critical care practitioners and researches to keep abreast of important information.

1. Introduction

Modern methods to search for important medial literature have recently flourished with the dissemination and near ubiquity of Internet-based search engines (eg, PubMed, MEDLINE, OVID). Articles that have been cited most often, referred to as "citation classics," are frequently important sources of both detailed information that has changed clinical/research practices as well as of useful connectors to other relevant literature that cites these articles. Finding landmarks or classic articles still requires an understanding of the literature and how articles are referenced. Different databases may categorize disciplines and journals from the same clinical areas under different terms and yield different results when using the same search term.

These referencing differences as well as other conceptual arguments have led to some debate regarding attributing the number of times an article is cited to its quality [1-4] However, there is general agreement that the number of times an article is cited does reflect the "impact of that article on the scientific market" [5].

Garfield [6] first published citation classics of the *Journal of the American Medical Association* in 1987. Similar studies (citations classic or impact factors) have been published with respect to various clinical specialties [7-15]. In 2004, Baltussen and Kindler [16] published citation classics of the critical care literature and enumerated the 71 top-cited articles in critical care journals and the 45 top-cited critical care articles in non–critical care journals. This article was somewhat limited by the number of citations referenced as

☆ This study was funded entirely by the Department of Anesthesiology, University of Michigan, Ann Arbor, Mich.

* Corresponding author. UMHS-Department of Anesthesiology, Ann Arbor, MI 48109-5861, USA. Tel.: +1 734 936 7241; fax: +1 734 232 4548.
E-mail address: arosen@med.umich.edu (A.L. Rosenberg).

0883-9441/$ – see front matter © 2010 Published by Elsevier Inc.
doi:10.1016/j.jcrc.2008.12.010

well as the absence of specific critical care topic citations groups. The first and primary aim of this study was to expand on Baltussen's earlier work and provide an updated and more comprehensive catalogue of the most influential articles pertaining to critical care medicine and *within* specific categories of critical care, something not done in previous studies of this type. We also examined the methods used to retrieve articles to provide an exhaustive search method that future researchers may use in modern electronic databases to find frequently cited critical care articles.

2. Methods

2.1. Creation of master comprehensive list

To develop the most comprehensive master list of most often cited critical care medicine–related articles, we first focused on querying the ISI Web of Knowledge (2008 Thompson Corporation) using the Science Citation Index Expanded (SCI Expanded) data set. The SCI Expanded is a database that provides bibliographic information, abstracts, references, and citations counts for more than 6650 scholarly science and technology journals. The SCI Expanded search was limited to articles published from 1900 to December 31, 2007. To find any article among the broadest selection of scientific journals related to critical care, we searched for any article that contained the keywords "critical-care," "intensive-care," "ICU," or "critically-ill OR critical-illness" and that had been cited more than 100 times. A total of 472 articles were retrieved with this technique after duplicates were removed (see Fig. 1A).

Because many critical care articles found in the SCI Expanded were not tagged by the general keywords noted above, we also searched *within* critical care journals. To do this, we used the Journal Citation Report (JCR) 2006 to identify journals specializing in critical care medicine from more than 7500 scholarly journals. We first reduced the target list to 16 English-language journals of 18 critical care journals identified by the JCR. We reviewed any article that had been cited more than 100 times and saved articles pertaining to critical care medicine (Fig. 1B). This search resulted in 470 hits; however, we removed 159 duplicate articles that were already found by keyword searches to bring the total database to 783 articles (Fig. 1).

2.2. Creation of disease/condition-specific lists

A representative list of most cited articles for each of the specific critical care topics was created from the existing database and by searching each topic individually using the terms in Table 1. Using these search terms, articles pertinent to

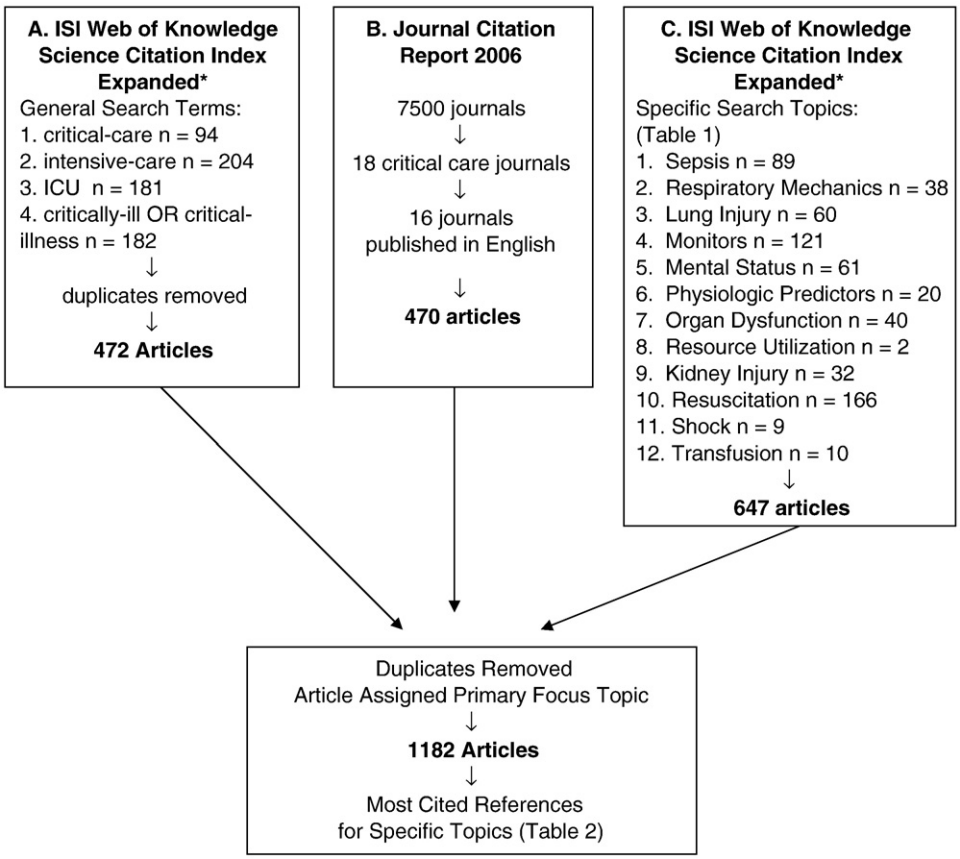

Fig. 1 Methods.

critical care and referenced more than 100 times were added to the database. These searches by specific disease or conditions added 404 articles to the master database as 194 articles were already in the database from either the initial search or from the journal search. From this master database of 1187 articles, we then generated a list of all articles cited more than 150 times (Table 2). We organized this table by topics particularly relevant to critical care. Within each category we listed both the most cited articles within that topic as well as that article's ranking within the top 200 most cited articles. Finally, we also listed the absolute number of citations for each article.

3. Results

The final database included 1187 articles (Fig. 1). The articles collated in this study came from almost 100 different journals with publication years ranging from 1905 (#149) to 2006 (average publication year = 1991). Surprisingly, of the top 1000 most cited critical care articles, 662 were *not* found using any of the basic critical care search terms—critical care, intensive care, ICU, or critically ill/critical illness. These articles were discovered only after searching within a specific critical care journal (n = 227) or by specific critical care topics (Table 1) (n = 373). In fact, only 4 of the top 1000 articles could be found using any 1 of the 4 basic critical care terms listed above. Of these search terms, the most productive was "intensive care" (25 of top 100 articles), then "critically ill" or "critical illness" (19/100), "ICU" (11/100), and finally "critical care" (5/100). Sepsis/systemic inflammatory response syndrome was the most common topic (193 articles), followed by acute lung injury and mechanical ventilation (177 articles). Overall, 41% of the most cited articles came from critical care journals as designated by the JCR. The most articles were from *Critical Care Medicine* (23%) followed by *American Journal of Respiratory and Critical Care* (7%), *Journal of Trauma* (5%), *Intensive Care Medicine* (4%), and *Shock* (1%). Among the non–critical care journals, the *New England Journal of Medicine* (11%) followed by *JAMA* (9%) provided the most articles.

Table 1 Specific critical care subjects

Subject area	Search terms
Sepsis and infectious disease	"sepsis" "septic*" "nosocomial" "blood stream"
Mechanical ventilation and lung injury	"ventilation" "respiratory failure" "pulmonary failure" "weaning" "extubation" "ventilator" "PEEP" "positive end expiratory pressure" "noninvasive" "ARDS" "respiratory-distress" "lung injury"
Monitors	"hemodynamic-monitor" "CVC" "physiologic-monitor" "noninvasive-monitor" "catheter*" "central venous" "pulmonary-artery-catheter" "Swan-Ganz" "ultrasound" "Doppler" "pressure variation"
Mental status	"coma" "brain-damage" "brain-injury" "ICU AND delirium" "ICU AND sedation"
Physiologic predictors	"physiology score" "severity of illness" "severity of disease" "mortality-predict" "severity-score"
Organ dysfunction	"organ-failure" "organ-dysfunction" "MODS" "MSOF"
Resource utilization	"intensivist" "leap frog" "ICU-administration" "critical care management" "ICU management"
Kidney injury	"kidney-injury" "renal-failure" "dialysis" "renal-replacement-therapy" "CVVH*" "CRRT"
Resuscitation	"life-support" "cardiac-arrest" "cpr" "resuscitation" "cardiac massage" "cardiac-life-support" "fluid" "saline" "lactated" "albumin" "colloid" "crystalloid"
Shock (excluding infectious causes)	"shock" "hypoperfusion" "CHF" "heart-failure"
Transfusions	"transfusion" "fluid-therapy"

*Denotes any form of the word preceding the symbol, i.e., septic shock, septic.

4. Discussion

One method to quickly retrieve scholarly articles related to critical care medicine is by using readily available, Internet-based, bibliographic database search tools supported by most medical libraries. We have found, however, that commonly used basic search terms retrieve under only 50% of the most cited and therefore arguably most influential articles in critical care. Therefore, although searches may have become much faster and easier, they may not be sufficient to retrieve a comprehensive list of articles.

We found that there is no single term that exhaustively retrieves all critical care medicine articles. The best generic search term, "intensive care," only retrieved 25% of what one would consider the 100 of the most influential articles in critical care. Furthermore, the search term "critical care" was linked to only 5 of the top 100 articles, although it is a common keyword used by many search engines. Not to mention the fact that it is in the title of 8 of the 18 "critical care" journals.

One goal of this study was to determine the most efficient search terms for future literature searches. The capriciousness of how efficient a search term is perhaps no better illustrated than with our experience retrieving articles on ICU mortality prediction models. That not one of the basic critical care search terms in the Science Citation Index was tagged to these most influential articles highlights some of the difficulties in finding the most cited studies in critical care. It is clear that even for other types of articles, the best yield of

Table 2 Most cited articles in critical care medicine by subject

Overall Citation Rank
A. Sepsis/systemic inflammatory response syndrome (no. of times cited)
1. (#6) Tracey, KJ et al. Anti-cachectin TNF monoclonal-antibodies prevent septic shock during lethal bacteremia. *Nature* 1987. (1983)
2. (#7) Bone, RC et al. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Chest* 1992. (1838)
3. (#8) Bernard, GR et al. Efficacy and safety of recombinant human activated protein C for severe sepsis. *N Engl J Med* 2001. (1827)
4. (#10) Bone, RC et al. American-College of Chest Physicians Society of Critical Care Medicine Consensus Conference—definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Crit Care Med* 1992. (1724)
5. (#12) Van den Berghe, G et al. Intensive insulin therapy in critically ill patients. *N Engl J Med* 2001. (1608)
6. (#19) Ziegler, EJ et al. Treatment of gram-negative bacteremia and septic shock with HA-1a human monoclonal-antibody against endotoxin—a randomized, double-blind, placebo-controlled trial. *N Engl J Med* 1991. (1072)
7. (#22) Angus, DC et al. Epidemiology of severe sepsis in the United States: analysis of incidence, outcome, and associated costs of care. *Crit Care Med* 2001. (1016)
8. (#25) Bone, RC. The pathogenesis of sepsis. *Ann Intern Med* 1991. (982)
9. (#28) Waage, A et al. The complex pattern of cytokines in serum from patients with meningococcal septic shock—association between interleukin-6, interleukin-1, and fatal outcome. *J Exp Med* 1989. (892)
10. (#31) Wichterman, KA et al. Sepsis and septic shock—a review of laboratory models and a proposal. *J Surg Res* 1980. (846)
11. (#34) Bone, RC et al. A controlled clinical-trial of high-dose methylprednisolone in the treatment of severe sepsis and septic shock. *N Engl J Med* 1987. (791)
12. (#37) Parrillo, JE. Mechanisms of disease—pathogenetic mechanisms of septic shock. *N Engl J Med* 1993. (756)
13. (#41) Annane, D et al. Effect of treatment with low doses of hydrocortisone and fludrocortisone on mortality in patients with septic shock. *JAMA* 2002. (712)
14. (#43) Petros, A et al. Effect of nitric-oxide synthase inhibitors on hypotension in patients with septic shock. *Lancet* 1991. (705)
15. (#52) Cannon, JG et al. Circulating interleukin-1 and tumor necrosis factor in septic shock and experimental endotoxin fever. *J Infect Dis* 1990. (642)
16. (#55) Casey, LC et al. Plasma cytokine and endotoxin levels correlate with survival in patients with the sepsis syndrome. *Ann Intern Med* 1993. (624)
17. (#56) Vanzee, KJ et al. Tumor-necrosis-factor soluble receptors circulate during experimental and clinical inflammation and can protect against excessive tumor-necrosis-factor–alpha in vitro and in vivo. *Proc Nat Acad Sci USA* 1992. (600)
18. (#59) Hack, CE et al. Increased plasma-levels of interleukin-6 in sepsis. *Blood* 1989. (589)
19. (#62) Moore, FA et al. Early enteral feeding, compared with parenteral, reduces postoperative septic complications—the results of a metaanalysis. *Ann Surg* 1992. (578)
20. (#64) Lowenstein, CJ et al. Nitric-oxide—a physiological messenger. *Ann Intern Med* 1994. (574)
21. (#69) Fry, DE et al. Multiple system organ failure—role of uncontrolled infection. *Arch Surg* 1980. (549)
22. (#70) Parker, MM et al. Profound but reversible myocardial depression in patients with septic shock. *Ann Intern Med* 1984. (548)
23. (#72) Kudsk, KA et al. Enteral versus parenteral-feeding—effects on septic morbidity after blunt and penetrating abdominal-trauma. *Ann Surg* 1992. (543)
24. (#75) Fisher, CJ et al. Treatment of septic shock with the tumor necrosis factor receptor:Fc fusion protein. *N Engl J Med* 1996. (540)
25. (#77) Hotchkiss, RS et al. Medical progress: the pathophysiology and treatment of sepsis. *N Engl J Med* 2003. (538)
26. (#78) Greenman, RL et al. A controlled clinical-trial of E5 murine monoclonal IgM antibody to endotoxin in the treatment of gram-negative sepsis. *JAMA* 1991. (536)
27. (#81) Martin, GS et al. The epidemiology of sepsis in the United States from 1979 through 2000. *N Engl J Med* 2003. (529)
28. (#83) Glauser, MP et al. Septic shock—pathogenesis. *Lancet* 1991. (522)
29. (#89) Dellinger, RP et al. Surviving sepsis campaign guidelines for management of severe sepsis and septic shock. *Crit Care Med* 2004. (513)
30. (#94) Bone, RC et al. Sepsis syndrome—a valid clinical entity. *Crit Care Med* 1989. (506)
31. (#96) Fisher, CJ et al. Recombinant human interleukin-1 receptor antagonist in the treatment of patients with sepsis syndrome—results from a randomized, double-blind, placebo-controlled trial. *JAMA* 1994. (499)
32. (#97) Parrillo, JE et al. Septic shock in humans—advances in the understanding of pathogenesis, cardiovascular dysfunction, and therapy. *Ann Intern Med* 1990. (499)
33. (#105) Assicot, M et al. High serum procalcitonin concentrations in patients with sepsis and infection. *Lancet* 1993. (481)
34. (#109) Ochoa, JB et al. Nitrogen-oxide levels in patients after trauma and during sepsis. *Ann Surg* 1991. (464)
35. (#114) Moore, FA et al. TEN versus TPN following major abdominal-trauma–reduced septic morbidity. *J Trauma* 1997. (435)
36. (#120) Abraham, E et al. Efficacy and safety of monoclonal-antibody to human tumor necrosis-factor–alpha in patients with sepsis syndrome—a randomized, controlled, double-blind, multicenter clinical-trial. *JAMA* 1995. (425)

Table 2 (*continued*)

Overall Citation Rank

A. Sepsis/systemic inflammatory response syndrome (no. of times cited)

37. (#121) Meakins, JL et al. Delayed-hypersensitivity—indicator of acquired failure of host defenses in sepsis and trauma. *Ann Surg* 1977. (425)
38. (#122) Pinsky, MR et al. Serum cytokine levels in human septic shock—relation to multiple system organ failure and mortality. *Chest* 1993. (422)
39. (#131) Danner, RL et al. Endotoxemia in human septic shock. *Chest* 1991. (409)
40. (#132) Eickhoff, TC et al. Neonatal sepsis + other infections due to group b beta-hemolytic streptococci. *N Engl J Med* 1964. (408)
41. (#134) Wheeler, AP et al. Treating patients with severe sepsis. *N Engl J Med* 1999. (405)
42. (#151) Sprung, CL et al. The effects of high-dose corticosteroids in patients with septic shock—a prospective, controlled-study. *N Engl J Med* 1984. (386)
43. (#153) Damas, P et al. Cytokine serum level during severe sepsis in human il-6 as a marker of severity. *Ann Surg* 1992. (382)
44. (#157) Askanazi, J et al. Influence of total parenteral-nutrition on fuel utilization in injury and sepsis. *Ann Surg* 1980. (377)
45. (#162) Docke, WD et al. Monocyte deactivation in septic patients: restoration by IFN-gamma treatment. *Nature Med* 1997. (372)
46. (#168) Petros, A et al. Effects of a nitric-oxide synthase inhibitor in humans with septic shock. *Cardiovasc Res* 1994. (366)
47. (#173) BrunBuisson, C et al. Incidence, risk-factors, and outcome of severe sepsis and septic shock in adults—a multicenter prospective-study in intensive-care units. *JAMA* 1995. (361)
48. (#174) Nava, E et al. Inhibition of nitric-oxide synthesis in septic shock—how much is beneficial. *Lancet* 1991. (361)
49. (#178) Szabo, C. The pathophysiological role of peroxynitrite in shock, inflammation, and ischemia-reperfusion injury. *Shock* 1996. (350)
50. (#180) Warren, BL et al. High-dose a randomized antithrombin III in severe sepsis—a randomized controlled trial. *JAMA* 2001. (348)
51. (#181) Bone, RC. Sir Isaac Newton, Sepsis, SIRS, and cars. *Crit Care Med* 1996. (348)
52. (#182) Schumer, W. Steroids in treatment of clinical septic shock. *Ann Surg* 1976. (348)
53. (#183) Damas, P et al. Tumor necrosis factor and interleukin-1 serum levels during severe sepsis in humans. *Crit Care Med* 1989. (346)
54. (#185) Cohen, J et al. The immunopathogenesis of sepsis. *Nature* 2002. (345)
55. (#187) Rush, BF et al. Endotoxemia and bacteremia during hemorrhagic-shock—the link between trauma and sepsis. *Ann Surg* 1988. (341)
56. (#190) Fourrier, F et al. Septic shock, multiple organ failure, and disseminated intravascular coagulation—compared patterns of antithrombin-III, protein-C, and protein-S deficiencies. *Chest* 1992. (339)
57. (#192) Munoz, C et al. Dysregulation of in vitro cytokine production by monocytes during sepsis. *J Clin Invest* 1991. (336)

Table 2 (*continued*)

Overall Citation Rank

A. Sepsis/systemic inflammatory response syndrome (no. of times cited)

B. Outcome/benchmarking/prediction model articles (no. of times cited)

1. (#1) Knaus, WA et al. APACHE-II—a severity of disease classification-system. *Crit Care Med* 1985. (4909)
2. (#4) Baker, SP et al. Injury severity score—method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974. (2637)
3. (#13) Legall, JR et al. A new simplified acute physiology score (SAPS-II) based on a European North-American multicenter study. *JAMA* 1993. (1402)
4. (#14) Knaus, WA et al. The APACHE-III prognostic system—risk prediction of hospital mortality for critically ill hospitalized adults. *Chest* 1991. (1357)
5. (#21) Knaus, WA et al. A controlled trial to improve care for seriously ill hospitalized-patients—the study to understand prognoses and preferences for outcomes and risks of treatments (support). *JAMA* 1995. (1056)
6. (#26) Fine, MJ et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med* 1997. (965)
7. (#33) Deitch, EA. Multiple organ failure—pathophysiology and potential future therapy. *Ann Surg* 1992. (793)
8. (#36) Knaus, WA et al. APACHE-acute physiology and chronic health evaluation—a physiologically based classification-system. *Crit Care Med* 1981. (758)
9. (#38) Vincent, JL et al. The SOFA (sepsis-related organ failure assessment) score to describe organ dysfunction/failure. *Intens Care Med* 1996. (735)
10. (#40) Knaus, WA et al. An evaluation of outcome from intensive-care in major medical centers. *Ann Intern Med* 1986. (715)
11. (#47) Legall, JR et al. A simplified acute physiology score for ICU patients. *Crit Care Med* 1984. (667)
12. (#49) Boyd, CR et al. Evaluating trauma care—the TRISS method. *J Trauma* 2001. (658)
13. (#58) Marshall, JC et al. Multiple organ dysfunction score—a reliable descriptor of a complex clinical outcome. *Crit Care Med* 1995. (592)
14. (#63) Carrico, CJ et al. Multiple-organ-failure syndrome. *Arch Surg* 1986. (575)
15. (#80) Baker, SP et al. Injury severity score—update. *J Trauma* 1997. (532)
16. (#87) Champion, HR et al. A revision of the trauma score. *J Trauma* 1997. (516)
17. (#98) Pollack, MM et al. Pediatric risk of mortality (prism) score. *Crit Care Med* 1988. (498)

(*continued on next page*)

Table 2 (*continued*)

B. Outcome/benchmarking/prediction model articles (no. of times cited)

18. (#103) Champion, HR et al. Trauma score. *Crit Care Med* 1981. (486)
19. (#112) Keene, AR et al. Therapeutic intervention scoring system—update 1983. *Crit Care Med* 1983. (444)
20. (#115) Higgins, TL et al. Stratification of morbidity and mortality outcome by preoperative risk-factors in coronary-artery bypass patients—a clinical severity score. *JAMA* 1992. (435)
21. (#149) Lemeshow, S et al. Mortality probability-models (MPM-II) based on an international cohort of intensive-care unit patients. *JAMA* 1993. (388)
22. (#150) Champion, HR et al. The major trauma outcome study—establishing national norms for trauma care. *J Trauma* 1996. (386)
23. (#169) Takala, J et al. Increased mortality associated with growth hormone treatment in critically ill adults. *N Engl J Med* 1999. (365)
24. (#184) Vincent, JL et al. Use of the SOFA score to assess the incidence of organ dysfunction/failure in intensive care units: results of a multicenter, prospective study. *Crit Care Med* 1998. (346)
25. (#197) Faist, E et al. Multiple organ failure in polytrauma patients. *J Trauma* 1995. (332)
26. Moore, EE et al. Organ injury scaling—spleen, liver, and kidney. *J Trauma* 1995. (317)
27. Cockburn, F et al. The CRIB (clinical risk index for babies) score—a tool for assessing initial neonatal risk and comparing performance of neonatal intensive-care units. *Lancet* 1993. (273)
28. Greenspan, L et al. Abbreviated injury scale and injury severity score—a scoring chart. *J Trauma* 1993. (267)
29. Ware, JE et al. Comparison of methods for the scoring and statistical-analysis of SF-36 health profile and summary measures—summary of results from the medical outcomes study. *Med Care* 1995. (259)
30. Richardson, DK et al. Score for neonatal acute physiology—a physiological severity index for neonatal intensive-care. *Pediatrics* 1993. (252)
31. Moore, EE et al. Organ injury scaling—spleen and liver [1994 revision]. *J Trauma* 1993. (233)
32. Copes, WS et al. The injury severity score revisited. *J Trauma* 1988. (217)
33. Pollack, MM et al. PRISM III: an updated pediatric risk of mortality score. *Crit Care Med* 1996. (212)

C. Mechanical and positive pressure ventilation/airway articles (no. of times cited)

1. (#9) Brower, RG et al. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *N Engl J Med* 2000. (1750)
2. (#27) Amato, MBP et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. *N Engl J Med* 1998. (911)
3. (#42) Gregory, GA et al. Treatment of idiopathic respiratory-distress syndrome with continuous positive airway pressure. *N Engl J Med* 1971. (708)

Table 2 (*continued*)

C. Mechanical and positive pressure ventilation/airway articles (no. of times cited)

4. (#44) Suter, PM et al. Optimum end-expiratory airway pressure in patients with acute pulmonary failure. *N Engl J Med* 1975. (698)
5. (#53) Dreyfuss, D et al. Ventilator-induced lung injury—lessons from experimental studies. *Am J Resp Crit Care* 1992. (641)
6. (#65) Brochard, L et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary-disease. *N Engl J Med* 1995. (561)
7. (#85) Stauffer, JL et al. Complications and consequences of endotracheal intubation and tracheotomy—a prospective-study of 150 critically ill adult patients. *Am J Med* 1981. (517)
8. (#93) Ranieri, VM et al. Effect of mechanical ventilation on inflammatory mediators in patients with acute respiratory distress syndrome—a randomized controlled trial. *JAMA* 1999. (508)
9. (#106) Nash, G et al. Pulmonary lesions associated with oxygen therapy and artificial ventilation. *N Engl J Med* 1967. (478)
10. (#108) Bendixen, HH et al. Impaired oxygenation in surgical patients during general anesthesia with controlled ventilation —a concept of atelectasis. *N Engl J Med* 1963. (465)
11. (#111) Webb, HH et al. Experimental pulmonary-edema due to intermittent positive pressure ventilation with high inflation pressures. protection by positive end-expiratory pressure. *Amer Rev Resp Dis* 1974. (445)
12. (#113) Boyd, O et al. A randomized clinical-trial of the effect of deliberate perioperative increase of oxygen delivery on mortality in high-risk surgical patients. *JAMA* 1993. (439)
13. (#129) Muscedere, JG et al. Tidal ventilation at low airway pressures can augment lung injury. *Am J Resp Crit Care* 1994. (412)
14. (#135) Kumar, A et al. Continuous positive-pressure ventilation in acute respiratory failure—effects on hemodynamics and lung function. *N Engl J Med* 1970. (403)
15. (#138) Hickling, KG et al. Low mortality associated with low-volume pressure limited ventilation with permissive hypercapnia in severe adult respiratory-distress syndrome. *Intens Care Med* 1990. (402)
16. (#139) Aroroa, NS et al. Respiratory muscle strength and maximal voluntary ventilation in undernourished patients. *Amer Rev Resp Dis* 1982. (402)
17. (#142) Kolobow, T et al. Severe impairment in lung-function induced by high peak airway pressure during mechanical ventilation—an experimental-study. *Amer Rev Resp Dis* 1987. (398)
18. (#147) Haldine, JS et al. The regulation of the lung-ventilation. *J Physiol-London* 1905. (390)
19. (#154) Ashbaugh, DG et al. Continuous positive-pressure breathing (CPPB) in adult respiratory distress syndrome. *J Thorac Cardiov Surg* 1969. (382)
20. (#196) Bott, J et al. Randomized controlled trial of nasal ventilation in acute ventilatory failure due to chronic obstructive airways disease. *Lancet* 1993. (333)
21. Falke, KJ et al. Ventilation with end-expiratory pressure in acute lung-disease. *J Clin Invest* 1972. (325)

Table 2 (*continued*)

C. Mechanical and positive pressure ventilation/airway articles (no. of times cited)

22. Kramer, N et al. Randomized, prospective trial of noninvasive positive pressure ventilation in acute respiratory-failure. *Am J Resp Crit Care* 1995. (323)
23. Stewart, TE et al. Evaluation of a ventilation strategy to prevent barotrauma in patients at high risk for acute respiratory distress syndrome. *N Engl J Med* 1998. (322)
24. Yang, KL et al. A prospective-study of indexes predicting the outcome of trials of weaning from mechanical ventilation. *N Engl J Med* 1991. (322)
25. Gattinoni, L et al. Low-frequency positive-pressure ventilation with extracorporeal CO2 removal in severe acute respiratory-failure. *JAMA* 1986. (321)

D. Acute lung injury/adult respiratory distress syndrome articles (no. of times cited)

1. (#11) Bernard, GR et al. The American-European Consensus Conference on ARDS—definitions, mechanisms, relevant outcomes, and clinical-trial coordination. *Am J Resp Crit Care* 1994. (1627)
2. (#16) Ashbaugh, DG et al. Acute respiratory distress in adults. *Lancet* 1967. (1283)
3. (#17) Murray, JF et al. An expanded definition of the adult respiratory-distress syndrome. *Amer Rev Resp Dis* 1988. (1133)
4. (#18) Rossaint, R et al. Inhaled nitric-oxide for the adult respiratory-distress syndrome. *N Engl J Med* 1993. (1083)
5. (#32) Ware, LB et al. Medical progress—the acute respiratory distress syndrome. *N Engl J Med* 2000. (794)
6. (#46) Tate, RM et al. Neutrophils and the adult respiratory-distress syndrome. *Amer Rev Resp Dis* 1983. (668)
7. (#48) Montgomery, AB et al. Causes of mortality in patients with the adult respiratory-distress syndrome. *Amer Rev Resp Dis* 1985. (663)
8. (#51) Brigham, KL et al. Endotoxin and lung injury. *Amer Rev Resp Dis* 1986. (650)
9. (#57) Rinaldo, JE et al. Adult respiratory-distress syndrome —changing concepts of lung injury and repair. *N Engl J Med* 1982. (599)
10. (#68) Weiland, JE et al. Lung neutrophils in the adult respiratory-distress syndrome—clinical and pathophysiologic significance. *Amer Rev Resp Dis* 1986. (551)
11. (#77) Fowler, AA et al. Adult respiratory-distress syndrome —risk with common predispositions. *Ann Intern Med* 1983. (540)
12. (#88) Hammerschmidt, DE et al. Association of complement activation and elevated plasma-C5a with adult respiratory-distress syndrome—pathophysiological relevance and possible prognostic value. *Lancet* 1980. (515)
13. (#99) Lee, CT et al. Elastolytic activity in pulmonary lavage fluid from patients with adult respiratory-distress syndrome. *N Engl J Med* 1981. (497)
14. (#100) Bell, RC et al. Multiple organ system failure and infection in adult respiratory-distress syndrome. *Ann Intern Med* 1983. (495)
15. (#107) Poutanen, SM et al. Identification of severe acute respiratory syndrome in Canada. *N Engl J Med* 2003. (468)

Table 2 (*continued*)

D. Acute lung injury/adult respiratory distress syndrome articles (no. of times cited)

16. (#116) Pepe, PE et al. Clinical predictors of the adult respiratory-distress syndrome. *Am J Surg* 1982. (432)
17. (#128) Donnelly, SC et al. Interleukin-8 and development of adult respiratory-distress syndrome in at-risk patient groups. *Lancet* 1993. (413)
18. (#137) Clements, JA et al. Assessment of risk of respiratory-distress syndrome by a rapid test for surfactant in amniotic-fluid. *N Engl J Med* 1972. (403)
19. (#140) Suter, PM et al. High bronchoalveolar levels of tumor-necrosis-factor and its inhibitors, interleukin-1, interferon, and elastase, in patients with adult respiratory-distress syndrome after trauma, shock, or sepsis. *Amer Rev Resp Dis* 1992. (402)
20. (#144) Petty, TL et al. Adult respiratory distress syndrome—clinical features, factors influencing prognosis and principles of management. *Chest* 1971. (393)
21. (#146) Gregory, TJ et al. Surfactant chemical-composition and biophysical activity in acute respiratory-distress syndrome. *J Clin Invest* 1991. (392)
22. (#165) Milberg, JA et al. Improved survival of patients with acute respiratory-distress-syndrome (ARDS)—1983-1993. *JAMA* 1995. (370)
23. (#170) Bernard, GR et al. High-dose corticosteroids in patients with the adult respiratory-distress syndrome. *N Engl J Med* 1987. (365)
24. (#186) Lewis, JF et al. Surfactant and the adult respiratory-distress syndrome. *Amer Rev Resp Dis* 1993. (342)
25. (#191) Danek, SJ et al. The dependence of oxygen-uptake on oxygen delivery in the adult respiratory-distress syndrome. *Amer Rev Resp Dis* 1980. (337)
26. Weaver, TE et al. Function and regulation of expression of pulmonary surfactant-associated proteins. *Arch Surg* 1991. (336)

E. Infection disease articles (nonsepsis) (no. of times cited)

1. (#5) Garner, JS et al. CDC definitions for nosocomial infections, 1988. *Am J Infect Control* 1988. (2356)
2. (#23) Vincent, JL et al. The prevalence of nosocomial infection in intensive-care units in Europe—results of the European prevalence of infection in intensive-care (EPIC) study. *JAMA* 1995. (993)
3. (#35) Neiderman, MS et al. Guidelines for the management of adults with community-acquired pneumonia—diagnosis, assessment of severity, antimicrobial therapy, and prevention. *Am J Resp Crit Care* 2001. (772)
4. (#50) Niedermann, MS et al. Guidelines for the initial management of adults with community-acquired pneumonia —diagnosis, assessment of severity, and initial antimicrobial therapy. *Amer Rev Resp Dis* 1993. (655)
5. (#61) Fagon, JY et al. Nosocomial pneumonia in ventilated patients—a cohort study evaluating attributable mortality and hospital stay. *Am J Med* 1993. (580)
6. (#73) Edmond MB et al. Nosocomial bloodstream infections in United States hospitals: a three-year analysis. *Clin Infect Dis* 1999. (542)

(*continued on next page*)

Table 2 (*continued*)

E. Infection disease articles (nonsepsis) (no. of times cited)

7. (#79) Pittet, D et al. Nosocomial blood-stream infection in critically ill patients—excess length of stay, extra costs, and attributable mortality. *JAMA* 1994. (535)
8. (#82) McFarland, LV et al. Nosocomial acquisition of *Clostridium difficile* infection. *N Engl J Med* 1989. (524)
9. (#90) Driks, MR et al. Nosocomial pneumonia in intubated patients given sucralfate as compared with antacids or histamine type-2 blockers—the role of gastric colonization. *N Engl J Med* 1987. (511)
10. (#92) Craven, DE et al. Risk-factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. *Amer Rev Resp Dis* 1986. (510)
11. (#102) Fagon, JY et al. Nosocomial pneumonia in patients receiving continuous mechanical ventilation—prospective analysis of 52 episodes with use of a protected specimen brush and quantitative culture techniques. *Amer Rev Resp Dis* 1989. (489)
12. (#104) Torres, A et al. Incidence, risk, and prognosis factors of nosocomial pneumonia in mechanically ventilated patients. *Amer Rev Resp Dis* 1990. (483)
13. (#110) Richards, MJ et al. Nosocomial infections in medical intensive care units in the United States. *Crit Care Med* 1999. (446)
14. (#117) Evans, RS et al. A computer-assisted management program for antibiotics and other antiinfective agents. *N Engl J Med* 1998. (430)
15. (#124) BergogneBerezin, E et al. *Acinetobacter* spp. as nosocomial pathogens: microbiological, clinical, and epidemiological features. *Clin Microbiol Rev* 1996. (415)
16. (#125) Kollef, MH et al. Inadequate antimicrobial treatment of infections—a risk factor for hospital mortality among critically ill patients. *Chest* 1999. (415)
17. (#126) Bradford, PA et al. Extended-spectrum beta-lactamases in the 21st century: characterization, epidemiology, and detection of this important resistance threat. *Clin Microbiol Rev* 2001. (413)
18. (#130) Goldmann, DA et al. Strategies to prevent and control the emergence and spread of antimicrobial-resistant microorganisms in hospitals—a challenge to hospital leadership. *JAMA* 1996. (412)
19. (#141) Celis, R et al. Nosocomial pneumonia—a multivariate-analysis of risk and prognosis. *Chest* 1988. (399)
20. (#155) Mulligan, ME et al. Methicillin-resistant *Staphylococcus aureus*—a consensus review of the microbiology, pathogenesis, and epidemiology with implications for prevention and management. *Am J Med* 1993. (381)
21. (#158) Curry, CR et al. Fungal septicemia in patients receiving parenteral hyperalimentation. *N Engl J Med* 1971. (376)
22. (#164) Stoutenbeek, CP et al. The effect of selective decontamination of the digestive-tract on colonization and infection-rate in multiple trauma patients. *Intens Care Med* 1984. (370)
23. (#175) Cosgrove, SE et al. Comparison of mortality associated with methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* bacteremia: a meta-analysis. *Clin Infect Dis* 2003. (359)

Table 2 (*continued*)

E. Infection disease articles (nonsepsis) (no. of times cited)

24. (#177) Chastre, J et al. Ventilator-associated pneumonia. *Am J Resp Crit Care* 2002. (355)
25. (#188) Ibrahim, EH et al. The influence of inadequate antimicrobial treatment of bloodstream infections on patient outcomes in the ICU setting. *Chest* 2000. (341)
26. (#189) Becksague, C et al. Hospital outbreak of multidrug-resistant *Mycobacterium tuberculosis* infections—factors in transmission to staff and HIV-infected patients. *JAMA* 1992. (341)
27. Gerberding, J et al. National nosocomial infections surveillance (NNIS) system report, data summary from January 1990-May 1999, issued June 1999. *Am J Infect Control* 1999. (327)
28. Luna, CM et al. Impact of BAL data on the therapy and outcome of ventilator-associated pneumonia. *Chest* 1997. (327)
29. Andrew, CP et al. Diagnosis of nosocomial bacterial pneumonia in acute, diffuse lung injury. *Chest* 1981. (326)
30. Kollef, MH. Ventilator-associated pneumonia—a multivariate-analysis. *JAMA* 1993. (325)
31. Cardo, D et al. National nosocomial infections surveillance (NNIS) system report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004. (324)
32. Maki, DG et al. Prevention of central venous catheter-related bloodstream infection by use of an antiseptic-impregnated catheter—a randomized, controlled trial. *Ann Intern Med* 1997. (323)
33. Livornese, LL et al. Hospital-acquired infection with vancomycin-resistant *Enterococcus faecium* transmitted by electronic thermometers. *Ann Intern Med* 1992. (319)
34. Darouiche, RO et al. A comparison of two antimicrobial-impregnated central venous catheters. *N Engl J Med* 1999. (312)
35. Maki, DG et al. Prospective randomized trial of povidone-iodine, alcohol, and chlorhexidine for prevention of infection associated with central venous and arterial catheters. *Lancet* 1991. (309)
36. Mermel, LA. Prevention of intravascular catheter-related infections. *Ann Intern Med* 2000. (267)
37. Raad, I et al. Central venous catheters coated with minocycline and rifampin for the prevention of catheter-related colonization and bloodstream infections—a randomized, double-blind trial. *Ann Intern Med* 1997. (255)
38. Pearson, ML. Guideline for prevention of intravascular-device–related infections. *Infect Control Hosp Epidemiol* 1996. (225)
39. Cobb, DK et al. A controlled trial of scheduled replacement of central venous and pulmonary-artery catheters. *N Engl J Med* 1992. (179)

F. Hemodynamic monitoring/oxygen delivery articles (no. of times cited)

1. (#15) Swan, HJC et al. Catheterization of heart in man with use of flow-directed balloon-tipped catheter. *N Engl J Med* 1970. (1297)
2. (#20) Rivers, E et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. *N Engl J Med* 2001. (1058)

Table 2 (*continued*)

F. Hemodynamic monitoring/oxygen delivery articles (no. of times cited)

3. (#29) Connors, AF et al. The effectiveness of right heart catheterization in the initial care of critically ill patients. *JAMA* 1996. (890)
4. (#66) Wei, K et al. Quantification of myocardial blood flow with ultrasound-induced destruction of microbubbles administered as a constant venous infusion. *Circulation* 1998. (561)
5. (#84) Hayes, MA et al. Elevation of systemic oxygen delivery in the treatment of critically ill patients. *N Engl J Med* 1994. (522)
6. (#86) Gutierrez, G et al. Gastric intramucosal pH as a therapeutic index of tissue oxygenation in critically ill patients. *Lancet* 1992. (516)
7. (#101) Gattinoni, L et al. A trial of goal-oriented hemodynamic therapy in critically ill patients. *N Engl J Med* 1995. (489)
8. (#159) Bihari, D et al. The effects of vasodilation with prostacyclin on oxygen delivery and uptake in critically ill patients. *N Engl J Med* 1987. (375)
9. Maynard, N et al. Assessment of splanchnic oxygenation by gastric tonometry in patients with acute circulatory failure. *JAMA* 1993. (259)
10. Sandham, JD et al. A randomized, controlled trial of the use of pulmonary-artery catheters in high-risk surgical patients? *N Engl J Med* 2003. (247)
11. Bernstein, DP. A new stroke volume equation for thoracic electrical bioimpedance—theory and rationale. *Crit Care Med* 1986. (223)
12. Connors, AF et al. Evaluation of right-heart catheterization in the critically ill patient without acute myocardial-infarction. *N Engl J Med* 1983. (219)
13. Mitchell, JP et al. Improved outcome based on fluid management in critically ill patients requiring pulmonary-artery catheterization. *Amer Rev Resp Dis* 1992. (217)
14. Dalen, JE et al. Is it time to pull the pulmonary artery catheter? *JAMA* 1996. (208)
15. Marik, PE. Gastric intramucosal pH—a better predictor of multiorgan dysfunction syndrome and death than oxygen-derived variables in patients with sepsis. *Chest* 1993. (202)
16. Gore, JM et al. A community-wide assessment of the use of pulmonary-artery catheters in patients with acute myocardial-infarction. *Chest* 1987. (202)
17. Iberti, TJ et al. A multicenter study of physicians knowledge of the pulmonary-artery catheter. *JAMA* 1990. (198)
18. Tremper, KK et al. Trans-cutaneous oxygen monitoring of critically ill adults, with and without low flow shock. *Crit Care Med* 1981. (196)
19. Garcia, MJ et al. An index of early left ventricular filling that combined with pulsed Doppler peak E velocity may estimate capillary wedge pressure. *J Amer Coll Cardiol* 1997. (195)
20. Elliott, CG et al. Complications of pulmonary-artery catheterization in the care of critically ill patients—prospective-study. *Chest* 1979. (187)

Table 2 (*continued*)

F. Hemodynamic monitoring/oxygen delivery articles (no. of times cited)

21. Yu, MH et al. Effect of maximizing oxygen delivery on morbidity and mortality-rates in critically ill patients—a prospective, randomized, controlled-study. *Crit Care Med* 1993. (182)
22. Robin, ED. The cult of the Swan-Ganz catheter—overuse and abuse of pulmonary flow catheters. *Ann Intern Med* 1985. (181)
23. McCormick, PW et al. Noninvasive cerebral optical spectroscopy for monitoring cerebral oxygen delivery and hemodynamics. *Crit Care Med* 1991. (174)
24. Eisenberg, PR et al. Clinical-evaluation compared to pulmonary-artery catheterization in the hemodynamic assessment of critically ill patients. *Crit Care Med* 1984. (170)
25. Shah, KB et al. A review of pulmonary-artery catheterization in 6,245 patients. *Anesthesiology* 1984. (169)
26. Bernstein, DP. Continuous noninvasive real-time monitoring of stroke volume and cardiac-output by thoracic electrical bioimpedance. *Crit Care Med* 1986. (162)
27. Michard, F et al. Relationship between changes in arterial pulse pressure and fluid responsiveness in septic patients with acute circulatory failure. *Am J Resp Crit Care* 2000. (159)

G. Neurologic and sedation articles (no. of times cited)

1. (#2) Teasdale, G et al. Assessment of coma and impaired consciousness—practical scale. *Lancet* 1974. (3749)
2. (#3) Jennett, B et al. Assessment of outcome after severe brain-damage—practical scale. *Lancet* 1975. (2825)
3. (#71) Chesnut, RM et al. The role of secondary brain injury in determining outcome from severe head-injury. *J Trauma* 1993. (546)
4. (#95) Chan PH. Role of oxidants in ischemic brain damage. *Stroke* 1996. (500)
5. (#127) Jennett, B. Persistent vegetative state after brain-damage—syndrome in search of a name. *Lancet* 1972. (413)
6. (#148) Muizelaar, JP et al. Adverse-effects of prolonged hyperventilation in patients with severe head-injury—a randomized clinical-trial. *J Neurosurg* 1991. (390)
7. (#152) Kress, JP et al. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med* 2000. (383)
8. (#161) Cohen, WJ et al. Lithium-carbonate, haloperidol, and irreversible brain-damage. *JAMA* 1974. (373)
9. (#167) Rosner, MJ et al. Cerebral perfusion-pressure—management protocol and clinical results. *J Neurosurg* 1995. (368)
10. (#179) Hossmann, KA et al. Reversibility of ischemic brain-damage. *Arch Neurol* 1973. (350)
11. Broderick, JP et al. Volume of intracerebral hemorrhage—a powerful and easy-to-use predictor of 30-day mortality. *Stroke* 1993. (294)
12. Siesjo, BK. Mechanisms of ischemic brain-damage. *Crit Care Med* 1988. (291)

(*continued on next page*)

Table 2 (*continued*)

G. Neurologic and sedation articles (no. of times cited)

13. Levy, DE et al. Predicting outcome from hypoxic-ischemic coma. *JAMA* 1985. (282)
14. Smith, I et al. Propofol—an update on its clinical use. *Anesthesiology* 1994. (276)
15. Segredo, V et al. Persistent paralysis in critically ill patients after long-term administration of vecuronium. *N Engl J Med* 1992. (270)
16. Clifton, GL et al. A phase-II study of moderate hypothermia in severe brain injury. *J Neurotraum* 1993. (254)
17. Jacobi, J et al. Clinical practice guidelines for the sustained use of sedatives and analgesics in the critically ill adult. *Crit Care Med* 2002. (242)
18. Lewen, A et al. Free radical pathways in CNS injury. *J Neurotraum* 2000. (238)
19. Levy, DE et al. Prognosis in non-traumatic coma. *Ann Intern Med* 1981. (235)
20. Ledingham, IM et al. Influence of sedation on mortality in critically ill multiple trauma patients. *Lancet* 1983. (227)
21. Schwab, S et al. Early hemicraniectomy in patients with complete middle cerebral artery infarction. *Stroke* 1998. (226)
22. Brott, T et al. Early hemorrhage growth in patients with intracerebral hemorrhage. *Stroke* 1997. (225)
23. Teasdale, G et al. Assessment and prognosis of coma after head-injury. *Acta Neurochir* 1976. (223)
24. Rosner, MJ et al. Cerebral perfusion-pressure management in head-injury. *J Trauma* 1991. (212)

H. ICU management/resource utilization articles (no. of times cited)

1. (#148) Leape, LL et al. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. *JAMA* 1999. (331)
2. Needleman, J et al. Nurse-staffing levels and the quality of care in hospitals. *N Engl J Med* 2002. (312)
3. Danis, M et al. A prospective-study of advance directives for life-sustaining care. *N Engl J Med* 1991. (308)
4. Smedira, NG et al. Withholding and withdrawal of life support from the critically ill. *N Engl J Med* 1990. (292)
5. Albert, RK et al. Hand-washing patterns in medical intensive-care units. *N Engl J Med* 1981. (281)
6. Shortell, SM et al. The performance of intensive-care units—does good management make a difference. *Med Care* 1994. (256)
7. Aiken, LH et al. Lower Medicare mortality among a set of hospitals known for good nursing-care. *Med Care* 1994. (244)
8. Cullen, DJ et al. Survival, hospitalization charges and follow-up results in critically ill patients. *N Engl J Med* 1976. (234)
9. Thibault, GE et al. Medical intensive-care—indications, interventions, and outcomes. *N Engl J Med* 1980. (229)
10. Prendergast, TJ et al. Increasing incidence of withholding and withdrawal of life support from the critically ill. *Am J Resp Crit Care* 1997. (220)

Table 2 (*continued*)

H. ICU management/resource utilization articles (no. of times cited)

11. Pronovost, PJ et al. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA* 1999. (210)
12. Angus, DC et al. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease—can we meet the requirements of an aging population? *JAMA* 2000. (209)
13. Pronovost, PJ et al. Physician staffing patterns and clinical outcomes in critically ill patients—a systematic review. *JAMA* 2002. (204)
14. Landrigan, CP et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med* 2004. (200)
15. McQuillan, P et al. Confidential inquiry into quality of care before admission to intensive care. *Brit Med J* 1998. (193)
16. Cook, DJ et al. Determinants in Canadian health-care workers of the decision to withdraw life-support from the critically ill. *JAMA* 1995. (193)
17. Donchin, Y et al. A look into the nature and causes of human errors in the intensive-care unit. *Crit Care Med* 1995. (165)
18. Asch, DA et al. Decisions to limit or continue life-sustaining treatment by critical care physicians in the United States—conflicts between physicians practices and patients wishes. *Am J Resp Crit Care* 1995. (141)
19. Reynolds, HN et al. Impact of critical care physician staffing on patients with septic shock in a university hospital medical intensive-care unit. *JAMA* 1988. (135)
20. Carson, SS et al. Effects of organizational change in the medical intensive care unit of a teaching hospital—a comparison of "open" and "closed" formats. *JAMA* 1996. (134)

I. Acute kidney injury articles (no. of times cited)

1. (#91) Thadhani, R et al. Medical progress—acute renal failure. *N Engl J Med* 1996. (510)
2. (#146) Ronco, C et al. Effects of different doses in continuous veno-venous haemofiltration on outcomes of acute renal failure: a prospective randomised trial. *Lancet* 2000. (391)
3. (#160) Brivet, FG et al. Acute renal failure in intensive care units—causes, outcome, and prognostic factors of hospital mortality: a prospective, multicenter study. *Crit Care Med* 1996. (374)
4. (#171) Levy, EM et al. The effect of acute renal failure on mortality—a cohort analysis. *JAMA* 1996. (364)
5. Bonventre, JV. Mechanisms of ischemic acute-renal-failure. *Kidney Int* 1993. (286)
6. Anderson, RJ et al. Non-oliguric acute renal-failure. *N Engl J Med* 1977. (283)
7. Hakim, RM et al. Effect of the dialysis membrane in the treatment of patients with acute-renal-failure. *N Engl J Med* 1994. (282)
8. Mangano, CM et al. Renal dysfunction after myocardial revascularization: risk factors, adverse outcomes, and hospital resource utilization. *Ann Intern Med* 1998. (259)

Table 2 (*continued*)

I. Acute kidney injury articles (no. of times cited)

9. Koffler, A et al. Acute renal-failure due to nontraumatic rhabdomyolysis. *Ann Intern Med* 1976. (251)
10. Tomita, K et al. Plasma endothelin levels in patients with acute renal-failure. *N Engl J Med* 1989. (248)
11. Byrd, L et al. Radio contrast-induced acute renal-failure —clinical and pathophysiologic review. *Medicine* 1979. (244)
12. Miller, TR et al. Urinary diagnostic indexes in acute renal-failure. *Ann Intern Med* 1978. (243)
13. Better, OS et al. Early management of shock and prophylaxis of acute-renal-failure in traumatic rhabdomyolysis. *N Engl J Med* 1990. (242)
14. Liano, F et al. Epidemiology of acute renal failure: a prospective, multicenter, community-based study. *Kidney Int* 1996. (239)
15. Schiffl, H et al. Biocompatible membranes in acute-renal-failure—prospective case-controlled study. *Lancet* 1994. (234)
16. Firth, JD et al. Endothelin—an important factor in acute renal-failure. *Lancet* 1988. (226)
17. Stein, JH et al. Current concepts on pathophysiology of acute renal-failure. *Am J Physiol* 1978. (218)
18. Zager, RA. Rhabdomyolysis and myohemoglobinuric acute renal failure. *Kidney Int* 1996. (205)
19. Schiffl, H et al. Daily hemodialysis and the outcome of acute renal failure. *N Engl J Med* 2002. (195)
20. Star, RA. Treatment of acute renal failure. *Kidney Int* 1998. (195)
21. Thurau, K et al. Acute renal success—unexpected logic of oliguria in acute renal-failure. *Am J Med* 1976. (193)
22. Bellomo, R et al. Low-dose dopamine in patients with early renal dysfunction: a placebo-controlled randomised trial. *Lancet* 2000. (192)
23. Shusterman, N et al. Risk-factors and outcome of hospital-acquired acute-renal-failure—clinical epidemiologic-study. *Am J Med* 1987. (191)
24. Lauer, A et al. Continuous arteriovenous hemofiltration in the critically ill patient—clinical use and operational characteristics. *Ann Intern Med* 1983. (191)
25. Bellomo, R et al. Continuous venovenous hemofiltration with dialysis removes cytokines from the circulation of septic patients. *Crit Care Med* 1993. (187)

J. Resuscitation and cardiac arrest articles (no. of times cited)

1. (#24) Kouwenhoven, WB et al. Closed-chest cardiac massage. *JAMA* 1960. (987)
2. (#39) Holzer, M et al. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. *N Engl J Med* 2002. (716)
3. (#45) Bernard, SA et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. *N Engl J Med* 2002. (668)
4. (#60) Ruskin, JN et al. Out-of-hospital cardiac-arrest—electrophysiologic observations and selection of long-term anti-arrhythmic therapy. *N Engl J Med* 1980. (586)
5. (#67) Bedell, SE et al. Survival after cardiopulmonary resuscitation in the hospital. *N Engl J Med* 1983. (558)

Table 2 (*continued*)

J. Resuscitation and cardiac arrest articles (no. of times cited)

6. (#118) Zoll, PM et al. Resuscitation of the heart in ventricular standstill by external electric stimulation. *N Engl J Med* 1952. (427)
7. (#133) Eisenberg, MS et al. Cardiac-arrest and resuscitation —a tale of 29 cities. *Ann Emerg Med* 1990. (407)
8. (#136) Cummins, RO et al. Improving survival from sudden cardiac-arrest—the chain of survival concept—a statement for health-professionals from the Advanced Cardiac Life-Support Subcommittee and the Emergency Cardiac Care Committee, American-Heart-Association. *Circulation* 1991. (403)
9. (#143) Wilber, DJ et al. Out-of-hospital cardiac-arrest—use of electrophysiologic testing in the prediction of long-term outcome. *N Engl J Med* 1988. (396)
10. (#156) Melrose, DG et al. Elective cardiac arrest. *Lancet* 1955. (379)
11. (#176) Clifton, GL et al. Lack of effect of induction of hypothermia after acute brain injury. *N Engl J Med* 2001. (356)
12. (#193) Baum, RS et al. Survival after resuscitation from out-of-hospital ventricular-fibrillation. *Circulation* 1974. (336)
13. (#195) Siscovick, DS et al. The incidence of primary cardiac-arrest during vigorous exercise. *N Engl J Med* 1984. (335)
14. Kuck, KH et al. Randomized comparison of antiarrhythmic drug therapy with implantable defibrillators in patients resuscitated from cardiac arrest—the Cardiac Arrest Study Hamburg (CASH). *Circulation* 2000. (321)
15. Valenzuela, TD et al. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. *N Engl J Med* 2000. (317)
16. Becker, LB et al. Outcome of CPR in a large metropolitan-area—where are the survivors. *Ann Emerg Med* 1991. (295)
17. Cummins, RO et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac-arrest—the Utstein style—a statement for health-professionals from a task-force of the American-Heart-Association, the European-Resuscitation-Council, the Heart-and-Stroke-Foundation-of-Canada, and the Australian-Resuscitation-Council. *Circulation* 1991. (289)
18. Weil, MH et al. Difference in acid-base state between venous and arterial blood during cardiopulmonary-resuscitation. *N Engl J Med* 1986. (281)
19. Murphy, DJ et al. Outcomes of cardiopulmonary resuscitation in the elderly. *Ann Intern Med* 1989. (267)
20. Luu, M et al. Diverse mechanisms of unexpected cardiac-arrest in advanced heart-failure. *Circulation* 1989. (266)
21. Rudikoff, MT et al. Mechanisms of blood-flow during cardiopulmonary resuscitation. *Circulation* 1980. (263)
22. Murphy, DJ et al. The influence of the probability of survival on patients preferences regarding cardiopulmonary-resuscitation. *N Engl J Med* 1994. (258)
23. Myerburg, RJ et al. Clinical, electrophysiologic and hemodynamic profile of patients resuscitated from prehospital cardiac-arrest. *Am J Med* 1980. (257)

(*continued on next page*)

Table 2 (*continued*)

J. Resuscitation and cardiac arrest articles (no. of times cited)

24. Taffet, GE et al. In-hospital cardiopulmonary resuscitation. *JAMA* 1988. (253)
25. Blackhall, LJ. Must we always use CPR. *N Engl J Med* 1987. (247)

K. Resuscitation and fluid therapy articles (no. of times cited)

1. (#74) Bickell, WH et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med* 1994. (541)
2. (#119) Roberts, I. Human albumin administration in critically ill patients: systematic review of randomised controlled trials. *Brit Med J* 1998. (426)
3. (#123) Ring, J et al. Incidence and severity of anaphylactoid reactions to colloid volume substitutes. *Lancet* 1977. (422)
4. Finfer, S et al. A comparison of albumin and saline for fluid resuscitation in the intensive care unit. *N Engl J Med* 2004. (279)
5. Sort, P et al. Effect of intravenous albumin on renal impairment and mortality in patients with cirrhosis and spontaneous bacterial peritonitis. *N Engl J Med* 1999. (279)
6. Mattox, KL et al. Prehospital hypertonic saline dextran infusion for posttraumatic hypotension—the USA multicenter trial. *Ann Surg* 1991. (240)
7. Shierhout, G et al. Fluid resuscitation with colloid or crystalloid solutions in critically ill patients: a systematic review of randomised trials. *Brit Med J* 1998. (235)
8. Virgilio, RW et al. Crystalloid vs colloid resuscitation—is one better—randomized clinical-study. *Surgery* 1979. (235)
9. Finfer, S et al. A comparison of albumin and saline for fluid resuscitation in the intensive care unit. *N Engl J Med* 2004. (223)
10. Kramer, GC et al. Small-volume resuscitation with hypertonic saline dextran solution. *Surgery* 1986. (222)
11. Nakayama, S et al. Small-volume resuscitation with hypertonic saline (2,400 mosm/liter) during hemorrhagic-shock. *Circ Shock* 1984. (203)
12. Holcroft, JW et al. 3-percent NaCl and 7.5-percent NaCl/dextran 70 in the resuscitation of severely injured patients. *Ann Surg* 1987. (201)
13. Choi, PTL et al. Crystalloids vs. colloids in fluid resuscitation: a systematic review. *Crit Care Med* 1999. (182)
14. Vassar, MJ et al. A multicenter trial for resuscitation of injured patients with 7.5-percent sodium-chloride—the effect of added dextran-70. *Arch Surg* 1993. (151)
15. Hauser, CJ et al. Oxygen-transport responses to colloids and crystalloids in critically ill surgical patients. *Surg Gynecol Obstet* 1980. (145)
16. Wiedemann, HP et al. Comparison of two fluid-management strategies in acute lung injury. *N Engl J Med* 1998. (139)
17. Wikes, MM et al. Patient survival after human albumin administration—a meta-analysis of randomized, controlled trials. *Ann Intern Med* 2001. (138)
18. Baxter, CR et al. Physiological response to crystalloid resuscitation of severe burns. *Ann NY Acad Sci* 1968. (138)

Table 2 (*continued*)

J. Resuscitation and cardiac arrest articles (no. of times cited)

19. Vassar, MJ et al. 7.5-percent sodium-chloride dextran for resuscitation of trauma patients undergoing helicopter transport. *Arch Surg* 1991. (136)
20. Mazzoni, MC et al. Dynamic fluid redistribution in hyperosmotic resuscitation of hypovolemic hemorrhage. *Am J Physiol* 1988. (129)
21. Shortgen, F et al. Effects of hydroxyethylstarch and gelatin on renal function in severe sepsis: a multicentre randomised study. *Lancet* 2001. (120)
22. Velanovich, V et al. Crystalloid versus colloid fluid resuscitation—a meta-analysis of mortality. *Surgery* 1989. (119)
23. Gross, D et al. Is hypertonic saline resuscitation safe in uncontrolled hemorrhagic-shock. *J Trauma* 1988. (119)
24. Treib, J et al. An international view of hydroxyethyl starches. *Intens Care Med* 1999. (116)
25. Wade, CE et al. Efficacy of hypertonic 7.5% saline and 6% dextran-70 in treating trauma: a meta-analysis of controlled clinical studies. *Surgery* 1997. (110)
26. Simma, B et al. A prospective, randomized, and controlled study of fluid management in children with severe head injury: lactated ringer's solution versus hypertonic saline. *Crit Care Med* 1998. (107)

L. Transfusion medicine/hematology/bleeding articles (no. of times cited)

1. (#30) Hebert, PC et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. *N Engl J Med* 1999. (867)
2. (#54) Besarab, A et al. The effects of normal as compared with low hematocrit values in patients with cardiac disease who are receiving hemodialysis and epoetin. *N Engl J Med* 1998. (637)
3. (#163) Samama, MM et al. A comparison of enoxaparin with placebo for the prevention of venous thromboembolism in acutely ill medical patients. *N Engl J Med* 1999. (372)
4. (#166) Hastings, SPR et al. Antacid titration in prevention of acute gastrointestinal bleeding-controlled randomized trial in 100 critically ill patients. *N Engl J Med*, 1978. (369)
5. (#172) Priebe, JH et al. Antacid versus cimetidine in preventing acute gastrointestinal-bleeding-randomized trial in 75 critically ill patients. *N Engl J Med* 1980. (364)
6. Marik, PE et al. Effect of stored-blood transfusion on oxygen delivery in patients with sepsis. *JAMA* 1993. (302)
7. Vincent, JL et al. Anemia and blood transfusion in critically ill patients. *JAMA* 2002. (245)
8. Wu, WC, et al. Blood transfusion in elderly patients with acute myocardial infarction. *N Engl J Med* 2001. (235)
9. van de Watering, LMG. Beneficial effects of leukocyte depletion of transfused blood on postoperative complications in patients undergoing cardiac surgery—a randomized clinical trial. *Circulation* 1998. (234)
10. Rohrer, MJ et al. Effect of hypothermia on the coagulation cascade. *Crit Care Med* 1992. (213)
11. Horwich, TB et al. Anemia is associated with worse symptoms, greater impairment in functional capacity and a significant increase in mortality in patients with advanced heart failure. *J Amer Coll Cardiol* 2002. (206)

Table 2 (*continued*)

L. Transfusion medicine/hematology/bleeding articles (no. of times cited)
12. Hebert, PC et al. Is a low transfusion threshold safe in critically ill patients with cardiovascular diseases? *Crit Care Med* 2001. (161)
13. Moore, FA et al. Blood transfusion—an independent risk factor for postinjury multiple organ failure. *Arch Surg* 1997. (158)
14. Corwin, HL et al. The CRIT study: anemia and blood transfusion in the critically ill—current clinical practice in the United States. *Crit Care Med* 2004. (150)
15. Corwin, HL et al. Efficacy of recombinant human erythropoietin in critically ill patients—a randomized controlled trial. *JAMA* 2002. (147)
16. Ferrara, A et al. Hypothermia and acidosis worsen coagulopathy in the patient requiring massive transfusion. *Am J Surg* 1990. (144)
17. Rao, SV et al. Relationship of blood transfusion and clinical outcomes in patients with acute coronary syndromes. *JAMA* 2004. (139)
18. Corwin, HL et al. Efficacy of recombinant human erythropoietin in the critically ill patient: a randomized, double-blind, placebo-controlled trial. *Crit Care Med* 1999. (137)
19. Boffard, KD et al. Recombinant factor VIIa as adjunctive therapy for bleeding control in severely injured trauma patients: two parallel randomized, placebo-controlled, double-blind clinical trials. *J Trauma* 1984. (129)
20. Hebert, PC et al. Does transfusion practice affect mortality in critically ill patients? *Am J Resp Crit Care* 1997. (125)
21. Cosgriff, N et al. Predicting life-threatening coagulopathy in the massively transfused trauma patient: hypothermia and acidoses revisited. *J Trauma* 1997. (118)
22. Corwin, HL et al. RBC transfusion in the ICU—is there a reason. *Chest* 1995. (118)
23. Fitzgerald, RD et al. Transfusing red blood cells stored in citrate phosphate dextrose adenine-1 for 28 days fails to improve tissue oxygenation in rats. *Crit Care Med* 1997. (100)

Article's rankings listed by subgroup then by its position within the overall top 200 citations.

only 25% indicates the need for a comprehensive search strategy such as the one used in this study.

Although this is a problem for those looking for research articles, it can also be an issue for the way published research becomes cited by others. For example, articles without abstracts or very brief abstracts were often found only after using exact topic words found in the article's title or by starting a search from within a specific critical care journal itself. Our experience has been previously demonstrated where the choice of keywords and abstract construction significantly impacts the likelihood that an article will be found using modern electronic searches [17].

This study does highlight the importance of sepsis and infectious disease as well as respiratory physiology in critical care with more than half the articles falling into 1 of these 2 broad categories. On the other hand, the most cited article was related to physiologic predictors of morbidity and mortality and the next 3 articles were related to mental status.

4.1. Limitations

This study, like previous ones focusing on citations, has several limitations. Perhaps the most relevant is the debate as to what constitutes the most influential articles within a professional discipline [1,4,18]. Citation data found in all bibliographic databases rely not only on correctly acquiring cited references but also on the assumption that a primary study cites other references that are most relevant to the published article. It is likely that this study captured many of the classic articles in critical care as each article in our list of the top 200 articles was cited at least 300 times. Considering that 46% of articles published in medicine are never even cited, this is a remarkable observation [19]. Certainly, these articles deserve attention and must have made an indelible impact. However, this is not always the case. Authors may preferentially cite their or their colleagues' previous works both because of familiarity or to increase the citation of that article. Recent scholarship on social networks, especially in the age of accelerated knowledge transmission, suggests that there may be an enhanced level of "connectedness" related to these networks [20,21]. It is not known whether, or how, this connectedness may be influencing the dissemination and therefore the pattern of references within the critical care community or among specific critical care topics. However, it is possible that the pattern of some citations may reflect the influence of an individual, as some have referred to as the "ceremonial citation," rather than the specific findings within an article [16,22,23]. In addition, authors are more likely to cite articles of their own language [8,24] or articles that come from a highly cited journal. Not surprisingly, Baltussen found that among the most cited 45 articles, most of them came from non–critical care-focused journals [16]. Nevertheless, using citations as a proxy for influence and importance has both face validity and is supported by empiric data demonstrating that citation analyses correlate with articles with the highest quality hierarchies of evidence and research design [25].

Most importantly, the use of citations is also confounded by the effect of time from the year of publication [26] with peak of citations differing for different journals and areas of research. Once citations do peak, they eventually become part of common knowledge and are no longer cited. Previous studies suggest that articles peak 7 to 10 years after publication [15,26]. It has been suggested that "classic" articles are relevant to only a few decades and many important articles are lost to the passage of time [15]. These findings may be supported by the fact that among the top 200 articles in this study, 158 were published during or after 2000. It is probably too early to tell how electronic databases

will change the epidemiology of citation classics because it is easier to retrieve and perhaps cite influential articles than before the age of the Internet.

In conclusion, although Web-based search engines can produce lists of references within seconds to minutes, the utility of these searches can be quite limited as a complete end effective literature search remains an art. Periodic reviews of the literature may prove helpful to trainees mastering the most influential literature of our field as well as more established professionals searching for starting points for new investigations.

References

[1] Moed HF. The impact-factors debate: the ISI's uses and limits. Nature 2002;415:731-2.

[2] Seglen PO. Citation rates and journal impact factors are not suitable for evaluation of research. Acta Orthop Scand 1998;69:224-9.

[3] Moed HF, van Leeuwen TN. Impact factors can mislead. Nature 1996; 381:186.

[4] Tobin MJ. The role of a journal in a scientific controversy. Am J Respir Crit Care Med 2003;168:511.

[5] Gisvold SE. Citation analysis and journal impact factors—is the tail wagging the dog? Acta Anaesthesiol Scand 1999;43:971-3.

[6] Garfield E. 100 citation classics from the Journal of the American Medical Association. JAMA 1987;257:52-9.

[7] Loonen MP, Hage JJ, Kon M. Plastic surgery classics: characteristics of 50 top-cited articles in four plastic surgery journals since 1946. Plast Reconstr Surg 2008;121s:320e-7e.

[8] Paladugu R, Schein M, Gardezi S, Wise L. One hundred citation classics in general surgical journals. World J Surg 2002;26:1099-105.

[9] Fenton JE, Roy D, Hughes JP, Jones AS. A century of citation classics in otolaryngology-head and neck surgery journals. J Laryngol Otol 2002;116:494-8.

[10] Picknett T, Davis K. The 100 most-cited articles from JMB. J Mol Biol 1999;293:171-6.

[11] Hall GM. BJA citation classics 1945-1992. Br J Anaesth 1998;80:4-6.

[12] Strassels SA, Carr DB, Meldrum M, Cousins MJ. Toward a canon of the pain and analgesia literature: a citation analysis. Anesth Analg 1999;89:1528-33.

[13] Terajima K, Aneman A. Citation classics in anaesthesia and pain journals: a literature review in the era of the internet. Acta Anaesthesiol Scand 2003;47:655-63.

[14] Baltussen A, Kindler CH. Citation classics in anesthetic journals. Anesth Analg 2004;98:443-51 [table of contents].

[15] Aylward BS, Roberts MC, Colombo J, Steele RG. Identifying the classics: an examination of articles published in the journal of pediatric psychology from 1976-2006. J Pediatr Psychol 2008;33: 576-89.

[16] Baltussen A, Kindler CH. Citation classics in critical care medicine. Intensive Care Med 2004;30:902-10.

[17] Sieck GC. The "impact factor": what it means to the impact of applied physiology. J Appl Physiol 2000;89:865-6.

[18] Seglen PO. Why the impact factor of journals should not be used for evaluating research. BMJ 1997;314:498-502.

[19] Adams AB, Simonson D. Publication, citations, and impact factors of leading investigators in critical care medicine. Respir Care 2004;49: 276-81.

[20] Wasserman S, Faust K. Social network analysis: methods and applications. vol. ed. Cambridge (Mass): Cambridge University Press; 1994.

[21] Backstrom L, Huttenlocher D, Kleinberg J, Lan X. Proceedings of 12th International Conference on Knowledge Discovery in Data Mining. New York: ACM Press; 2006.

[22] MacRoberts MH, MacRoberts BR. Citation analysis and the science policy arena. Trends Biochem Sci 1989;14:8-12.

[23] Cole S. Citations and the evaluation of individual scientists. Trends Biochem Sci 1989;14:9-13.

[24] Bhandari M, Busse J, Devereaux PJ, Montori VM, Swiontkowski M, Tornetta III P, et al. Factors associated with citation rates in the orthopedic literature. Can J Surg 2007;50:119-23.

[25] Patsopoulos NA, Analatos AA, Ioannidis JP. Relative citation impact of various study designs in the health sciences. JAMA 2005;293: 2362-6.

[26] Marx W, Schier H, Wanitschek M. Citation analysis using online databases: feasibilities and shortcomings. Scientometrics 2001;52: 59-82.