Highly Cited Articles in Health Care Sciences and Services Field in Science Citation Index Expanded

A Bibliometric Analysis for 1958 – 2012

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Summary

Objective: This study aimed to identify and analyze characteristics of highly cited articles published in the Web of Science category of health care sciences and services from 1958 to 2012.

Methods: Articles that have been cited at least 100 times were assessed regarding publication outputs, distribution of outputs in journals, publications of authors, institutions, countries as well as citation life cycles of the articles with the highest total citations since its publication up to 2012 and the highest citations in 2012. Six bibliometric indicators were used to evaluate source countries, institutions, and authors. Total citations from the time the articles were first published to the end of 2012 and citations in 2012 only were applied. Additionally, Y-index was applied to evaluate publication characteristics of authors. A high percentage of authors had the same numbers of first author and corresponding author status of highly cited articles in health care sciences and services field.

Results: Results showed that 890 of the most highly referenced articles, published between 1977 and 2009, had been cited at least 100 times. *Medical Care* and *Journal of General Internal Medicine* published the most highly cited articles. The United States produced 76% of highly cited articles and also published the most number of independent, internationally collaborative, first authored, corresponding authored, and single author highly cited articles. The Harvard University was the most productive institute and was number one for the total highly cited articles, inter-institutionally collaborative articles, single institution articles, first author articles, and corresponding author articles.

Conclusions: The application of quantitative techniques in the analysis of highly cited articles can improve the researchers' understanding of the directions in health care sciences and services field. Y-index is useful for the evaluation of contributing authors.

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1. Introduction

There is a long history of health care sciences and services (HCSS) research, the sheer number of HCSS publications available, indicate the significance of this field. There were 83 journals listed in the Web of Science category of HCSS in Journal Citation Reports (JCR) in 2012; and 148,869 documents were found in these 83 journals from 1900 to 2012. The first two journals in HCSS, both launched in 1958, were Royal Society of Health Journal and Journal of School Health.

Medical informatics could help researchers find the relevant information in a large amount of data [1, 2]. Bibliometric analysis in HCSS using Science Citation Index Expanded or Social Science Citation Index databases has been increasing yearly. Windsor [3] published the first article in HCSS adapting bibliometric methodology to investigate worldwide adverse-reaction publication trend. Citation, as an association-of-ideas index, offers an approach to subject control of the literature of science [4]. It has been illustrated how citation data were increasingly being used by science analysts and policy makers as quantitative indicators to measure research performance at levels ranging from individual authors to entire nations [5, 6]. Citation level as a measure of value of a paper could be dated back to 1970s, and the papers with most citations were labeled as "citation classics" [7]. Citation provides an objective methodology for "ranking" articles [8]. Various studies attempted to identify and analyze the highly cited articles, especially in medical fields, such as *JAMA – Journal of the American Medical Association* [7],
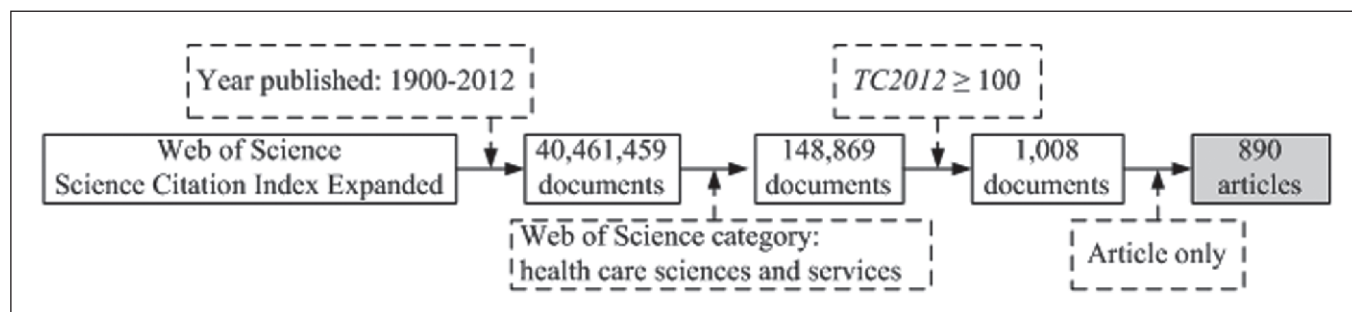
Figure 1   Schematic for searching the highly cited articles in health care sciences and services

leading dermatologic journals [9], journals dedicated to anaesthesia and pain [10], and ophthalmology journals [11]. Citation data are neutral, and its value and usefulness are realized in the appropriate, responsible, and informed interpretation of the data [12]. Properly applied, interpreted, and analyzed, citation data are a valuable and revealing addition to conventional quantitative and qualitative methods used in the science & technology evaluation and assessment process [13]. Highly cited articles [14], also called classic papers [15], and most frequently cited articles [16], represent the most significant developments in a specific field. Highly cited articles provide a substantial and valuable insight into which authors, articles, and topics are motivating the research field over time [17].

Various indicators were employed to characterize highly cited articles. The citations of articles was often used as an indicator of scientific performance in many medical fields [10]. Top cited articles were commonly listed to provide a basic source of information and were categorized according to publication year, journal, authors, countries, and institutions [18]. However, the number of citations of a paper is probably not sufficient to show the impact it had in the research field. In recent years, more indicators were developed, such as numbers of authors, numbers of institutions, numbers of countries and numbers of subject areas contributed to the total citations of one certain highly cited article for the Web of Science category of water resources [19], as well as the most frequently cited adsorption research articles [20]. The citation histories of papers give more details of the impact characteristics of articles [21]. In order to obtain de-

tails of articles' impact history, citation life cycles of highly cited articles were also considered important [22].

The articles analyzed in the present work were those in the field of health care sciences and services in Science Citation Index Expanded, having at least 100 citations. This study identified and examined the characteristics covering publication year, journals, authors, institutions, countries, life citation cycles, and attributes of the top cited articles.

2. Methodology

2.1 Data Collection

The methodology used in this study was based on the Science Citation Index Expanded (SCI-EXPANDED) database of Web of Science from Thomson Reuters (updated on 24 July 2013). According to Journal Citation Reports (JCR) of 2012, 8,471 journals were indexed in 176 categories of the Web of Science, science edition. The schematic for searching process of highly cited articles is shown in ▶ Figure 1. There were 40,461,459 documents from 1900 to 2012 found in SCI-EXPANDED. Results were refined by the Web of Science category of health care sciences and services (148,869 documents). $C2012$ denotes the total citations only in 2012 [23]. $TC2012$ denotes the total citations since publication of the article up to the end of 2012 [19]. $TC2012 \geq 100$ was used as a filter to extract the highly cited documents (1,008 documents). Documents with $TC2012 \geq 100$ were downloaded showing the total annual citations for each article. Therefore, 0.68% of the total documents published in the Web of Science cat-

egory of health care sciences and services are regarded as the highly cited papers including articles (890; 88%) which includes 98 proceedings papers, reviews (98; 10%), editorial materials (12, 1.2%), notes (6, 0.60%), and one for each of letter and reprint, respectively. The document type of proceeding paper was included in the document type of article according to Web of Science. The 890 articles having $TC2012 \geq 100$ were retrieved as highly cited articles for further analysis.

All results were manually calculated by self-designed algorithms and built-in functions ad graphed using Microsoft Excel 2010 for visual representation. In the Web of Science database, the corresponding author is designated as the "reprint author"; this study will hereby use the term "corresponding author" [24]. In a single author article where authorship is unspecified, the single author is both first and corresponding author [23]. Similarly, in a single institutional article, the institute is classified as the first as well as the corresponding author institute [25]. In subsequent analysis, articles originating from England, Scotland, Northern Ireland, and Wales were classified as being from the United Kingdom (UK) [26]. Articles from Federal Republic of Germany (Fed Rep Ger) and Germany were reclassified as being from Germany [23].

2.2 Indicators

The contributions from institutions and countries were identified by the appearance of at least one author in the publications. Collaboration type was determined from the affiliation of the authors [25]. The articles were classified into six types based on

the country and institution: 1) *TP*: the number of "total articles" of an institute or a country; 2) *IP*: the number of "single country article", if the researchers' affiliations were from the same country or "single institute article", if the researchers' affiliations were from the same institute; 3) *CP*: the number of "internationally collaborative article", if the articles were co-authored by researchers from multiple countries [26] or "inter-institutionally collaborative article", if authors were from different institutions; 4) *FP*: the number of "first author article", if the first author was from the country or institute for analysis; 5) *RP*: the number of "corresponding author article", if the corresponding author was from the country or institute for analysis; and, 6) *SP*: "single author article", if the author is the only one author in an article.

A newly developed indicator Y-index (*j*, *h*), which innovatively considered two prominent authorships, first author and corresponding author, has been applied to evaluate publication characteristics of authors for highly cited articles [23, 25]. The first author contributes most and writes the article, while corresponding author supervises processes and also writes the paper. For instance, at the institutional level, the determined institution of the corresponding author might be a home base of the study or origin of the paper [23]. Y-index could minimize the contribution dilution of increasing number of author in one publication and is appropriate for the evaluation of contributors to highly cited articles [27]. In our study, the role participated of each author was measured by Y-index. Y-index (*j*, *h*) is related to numbers of first

author publications (*FP*) and corresponding author publications (*RP*), defined as:

$$j = FP + RP \tag{1}$$

$$h = \tan^{-1}\left(\frac{RP}{FP}\right) \tag{2}$$

where *j* is publication performance, which is a constant related to publication quantity with important author positions (first and corresponding authors) articles only; and *h* is publication character, which can describe the proportion of *FP* to *RP*. An author with a higher *j* indicates more publications as first or corresponding author, playing the leadership role. *h*, differentiates the nature of the leadership role. When *h* > 0.7854, indicates more corresponding author publications and *h* < 0.7854, means more first author publications. When *h* = 0,
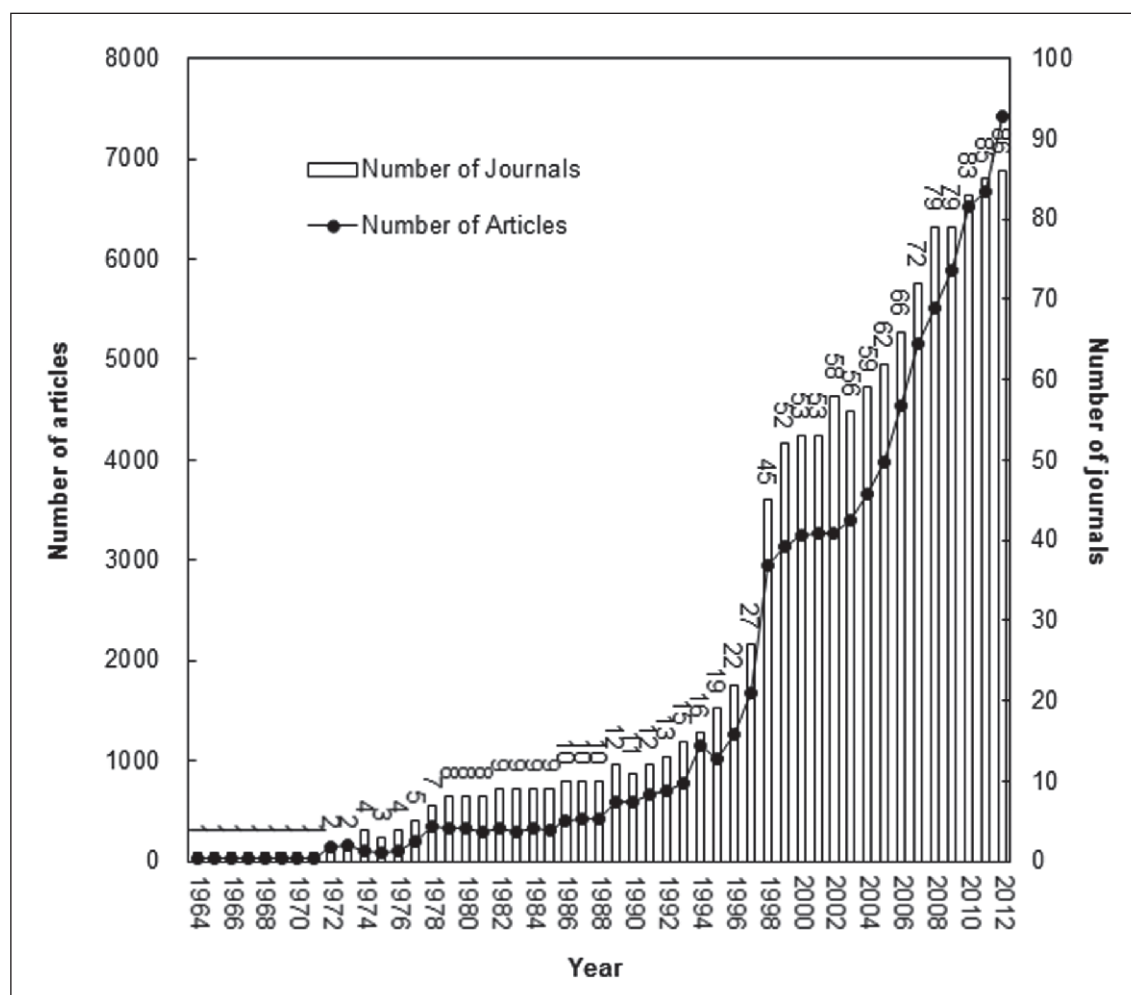

Figure 2
Number of total articles and journals during 1964–2012

j = the number of first author publications and when $h = \pi/2$, j = the number of corresponding author publications. The h could be easier presented and compared in the form of the degree of one angle than simple proportion of *FP* to *RP* in rectangular coordinates. One unique advantage for h is its efficiency in identifying publication characteristics by the distribution of Y-index (j, h) for contributors in a figure. Only articles with both first author and corresponding author information could be considered for calculating Y-index.

3. Results

3.1 Publication Year

To gain deeper insight into highly cited articles, the trends of total articles and their journals during 1958–2012 in HCSS

field in SCI-EXPANDED (updated on 2014-04-18) are identified and analyzed (▶ Figure 2). There are 82,012 articles in HCSS field, and the earliest HCSS article could be found in 1964. The number of journals available in the HCSS field from 1964–1971 was only one (*Methods of Information in Medicine*). This number increased to ten by 1986. The journal numbers then jumped from 27 in 1997 to 45 in 1998, by 2012 there were 86 journals available in the HCSS field. The subsequent increase in journal numbers leads to a similar pattern in available articles. In 1964–1971 the number of articles ranged from 20–30, but by 1986 there was an increase to over 400. There were further increases from 1,684 in 1997 to 2,954 in 1998, with available articles reaching 7,427 in 2012. The decade with the most articles was the 2000s, which had 41,924 articles

(51%), followed by the decade of the 2010s with 20,641 articles (25%), and the decade of the 1990s with 13,981 articles (17%). The earliest three decades 1960s, 1970s, and 1980s, accounted for only 6.7% in total.

A total of 890 highly cited articles (*TC2012* ≥100) had records in health care sciences and services field in SCI-EXPANDED. These articles were published between 1977 and 2009. *TC2012* ranged from 100 to 12,380 citations, and the mean number of citations per publication (*CPP*) is 208. ▶ Figure 3 illustrates the distribution of these 890 highly cited articles over the years, and their *CPP*. No highly cited articles have yet emerged in the latest three years (2010–2012). Only 11 of the highly cited articles were published prior to 1970s, while 45% of the highly cited articles appeared in 2000s, which is reflective of the percentage of total available articles (51%).

The mean number of *CPP* for the top 100 cited articles was 699 times, which could be attributed to the article by Ware and Sherbourne in 1992 with a *TC2012* of 12,380. *CPP* of a research field could be higher when few classic articles had extremely high citations. In particular, the decade of the 1970's with 11 articles having a *CPP* of 176, which was similar to the *CPP*'s of the other three decades ranged from 171 to 242. The earliest highly cited article in health care sciences and services field was "Computer-based audit to detect and correct over-utilization of laboratory tests" [28] published by *Medical Care* in 1977. The most recent highly cited articles were published in 2009 including Finkelstein et al. [29] with *TC2012* = 252, Coleman et al. [30] with *TC2012* = 146, and Damschroder et al. [31] with *TC2012* = 112.

3.2. Journal

The highly cited articles were published by 49 journals in the Web of Science category of health care sciences and services. Four of the 49 journals were not listed in the category of health care sciences and services in 2012 JCR including *Socioeconomic Status and Health in Industrial Nations: Social,* *Psychological, and Biological Pathways* which had nine highly cited articles listed in Web of Science in 1999 only; *Quality in Health Care* with four articles from 1996 to 2001; *Health Care Financing Review* (1994–2009) with three articles, and *Cancer Practice* (1997–2002) with only one article. Forty-five journals (54% of 83 journals) were listed in the category of health care sciences and services in 2012 JCR. The impact factor (*IF2012*) of a journal according to JCR for the year 2012 was determined. The top 100 highly cited articles in health care sciences and services field were distributed in 23 journals. Of these 45 journals, *Milbank Quarterly* (*IF2012* = 4.644), *Health Affairs* (*IF2012* = 4.641), and *Health Technology Assessment* (*IF2012* = 4.028) were the journals with impact factor higher than four. Thirty-seven journals (45% of 83 journals) had no highly cited articles and 14 journals (17%) had only one highly cited article. *Medical Care* published the most highly cited articles with 285 articles (32%), followed by *Journal of General Internal Medicine* with 113 articles (13%), while their impact factors were 3.227 (ranked 9th out of 83 journals) and 3.278 (ranked 8th out of 83 journals) respectively (▶Table 1). It can be noted that the journal in 10th position *Methods of Information in Medicine* had the longest publication history in health care sciences and services in SCI-EXPANDED, starting from 1964. However, highly cited articles in health care sciences and services field could also be found in journals with lower impact factors, such as *Bulletin of the History of Medicine* (*IF2012* = 0.594; 80/83), *Inquiry – The Journal of Health Care Organization Provision and Financing* (*IF2012* = 0.842; 71/83), and *Teaching and Learning in Medicine* (*IF2012* = 0.935; 68/83) with one article.

3.3 Authors, Institutions, and Countries

The results of author analysis could identify those researchers who have made significant contributions. Among the 2,887 authors contributing to 890 highly cited articles, 2,336 authors (81%) published only one highly cited article; 351 authors (12%) published two articles; 112 authors (3.9%) published three articles; 37 authors (1.3%) published four articles; and 51 authors published five or more of the highly cited articles. ▶Table 2 lists the authors with eight or more highly cited articles with four indicators including total number of highly cited articles, first author articles, corresponding author articles, and single author articles. It has been accepted convention among the experimental sciences that the most important authorship positions are the first and the last, who very often is the corresponding author [32]. The first author is the person who contributed most to the work, including conducting research and writing of the manuscript [33]. The corresponding author responsibilities include supervision of the planning and execution of the study, along with writing the paper [34]. J. E. Ware published not only the most highly cited articles but also the most first author and corresponding author highly cited articles. The only single author article was published by J. E. Ware in ▶Table 2. In addition, J. E. Ware published the three most cited articles entitled "The MOS 36-Item short-form health survey (SF-36). I. Conceptual-framework and item selection" [35] with *TC2012* = 12,380, "A 12-item short-form health survey: Con-

Journal	*TP* (%)	*IF2012* (rank)
Medical Care	285 (32)	3.227 (9)
Journal of General Internal Medicine	113 (13)	3.278 (8)
Health Affairs	56 (6.3)	4.641 (2)
Medical Decision Making	53 (6.0)	2.890 (12)
Journal of Pain and Symptom Management	50 (5.6)	2.601 (16)
Academic Medicine	46 (5.2)	3.292 (7)
Quality of Life Research	38 (4.3)	2.412 (18)
Medical Education	29 (3.3)	3.546 (6)
Health Services Research	24 (2.7)	2.291 (22)
Quality & Safety in Health Care	21 (2.4)	2.160 (27)
Journal of Health Economics	19 (2.1)	1.600 (43)
Health Economics	17 (1.9)	2.232 (24)
Milbank Quarterly	15 (1.7)	4.644 (1)
Value in Health	11 (1.2)	2.191 (26)
Methods of Information in Medicine	10 (1.1)	1.600 (43)

Table 1
Characteristics of 16 journals in health care sciences and services field with the highly cited articles (*TP* ≥10)

TP: total number of included highly cited articles; *IF2012*: impact factor of a journal according to JCR for the year 2012

Table 2   Thirteen highly productive authors of five or more classic articles

Author	Rank (*TP*)	Rank (*FP*)	Rank (*RP*)	Rank (*SP*)
Ware, J.E.	1 (25)	1 (7)	1 (7)	12 (1)
Patrick, D.L.	2 (11)	4 (4)	3 (4)	N/A
Hays, R.D.	2 (11)	31 (2)	29 (2)	N/A
Brook, R.H.	4 (10)	31 (2)	29 (2)	N/A
Stewart, A.L.	5 (9)	31 (2)	29 (2)	N/A
Norman, G.R.	5 (9)	4 (4)	3 (4)	N/A
Iezzoni, L.I.	7 (8)	128 (1)	N/A	N/A
Weinstein, M.C.	7 (8)	31 (2)	29 (2)	N/A
Vonkorff, M.	7 (8)	N/A	N/A	N/A
Bruera, E.	7 (8)	4 (4)	3 (4)	N/A

TP: total number of included highly cited articles; *FP*: number of included first author highly cited articles; *RP*: number of included corresponding author highly cited articles; *SP*: number of included single author highly cited articles; N/A: not available

struction of scales and preliminary tests of reliability and validity" [36] with *TC2012* = 3,747 as both the first author and corresponding author, and "The MOS 36-item short-form health survey (SF-36). II. Psychometric and clinical-tests of validity in measuring physical and mental-health constructs" [37] with *TC2012* = 2,830.

The 879 highly cited articles were further analyzed regarding institutions and countries using the author address information in the Web of Science. The 879 articles originated from a total of 842 institutions in 28 countries. ▶Table 3 shows the top 20 institutions. Harvard University ranks number 1 with 94 articles. It also published the most single institution articles and inter-institutionally collaborative articles as well as first and corresponding

Table 3
Characteristics of the 20 most productive institutions

Institution	Rank (*TP*)	Rank (*IP*)	Rank (*CP*)	Rank (*FP*)	Rank (*RP*)	Rank (*SP*)
Harvard University, USA	1 (94)	1 (17)	1 (77)	1 (43)	1 (35)	2 (4)
University of California, Los Angeles, USA	2 (49)	6 (9)	2 (40)	3 (22)	2 (22)	17 (1)
University of Washington, USA	3 (45)	2 (14)	3 (31)	3 (22)	3 (20)	1 (5)
Johns Hopkins University, USA	4 (37)	3 (12)	6 (25)	2 (23)	4 (19)	6 (2)
Mcmaster University, Canada	4 (37)	3 (12)	6 (25)	5 (20)	5 (16)	6 (2)
University of California, San Francisco, USA	6 (35)	8 (8)	4 (27)	6 (16)	6 (15)	17 (1)
RAND Corporation, USA	7 (32)	11 (5)	4 (27)	8 (14)	8 (14)	6 (2)
Brigham and Women's Hospital, USA	8 (27)	11 (5)	8 (22)	12 (10)	10 (10)	N/A
University of Michigan, USA	9 (26)	6 (9)	10 (17)	7 (15)	6 (15)	2 (4)
University of Toronto, Canada	10 (24)	5 (10)	19 (14)	10 (11)	23 (6)	17 (1)
University of North Carolina, USA	11 (21)	10 (6)	14 (15)	12 (10)	14 (8)	17 (1)
University of Wisconsin, USA	12 (20)	9 (7)	23 (13)	9 (13)	9 (11)	6 (2)
University of Pennsylvania, USA	12 (20)	15 (4)	12 (16)	12 (10)	13 (9)	17 (1)
University of Texas, USA	14 (19)	58 (1)	9 (18)	25 (6)	23 (6)	17 (1)
Yale University, USA	15 (18)	19 (3)	14 (15)	16 (9)	18 (7)	6 (2)
National Cancer Institute (NCI), USA	15 (18)	32 (2)	12 (16)	12 (10)	10 (10)	N/A
Veterans Admin Medical Center, USA	15 (18)	58 (1)	10 (17)	10 (11)	10 (10)	17 (1)
Duke University, USA	18 (17)	19 (3)	19 (14)	20 (7)	18 (7)	17 (1)
Northwestern University, USA	18 (17)	32 (2)	14 (15)	32 (5)	32 (5)	17 (1)
Stanford University, USA	18 (17)	32 (2)	14 (15)	37 (4)	37 (4)	17 (1)

TP: total number of included highly cited articles; *IP*: number of included single institute articles; *CP*: number of included inter-institutionally collaborative articles; *FP*: number of included first author articles; *RP*: number of included corresponding author articles; *SP*: number of included single author articles; N/A: not available.

author articles, while University Washington had the most single author articles. Of the total articles, 348 articles (40%) came from single institutions themselves and 531 articles (60%) from inter-institutional collaborations.

Authors' information was available for 879 articles (99% of 890 articles) which were contributed by 28 countries. In total 112 articles (13% of 879 articles) were international collaborations and they were contributed by 27 countries. The other 767 (87%) articles were contributed to by 15 countries. The characteristics of the top ten countries that published the most highly cited articles are illustrated in ▶Table 4. The leading country was USA (670 articles), accounting for 76%, followed by Canada (118 articles) and the UK (101 articles). Nine of 28 countries published only one highly cited article. Of the 112 internationally collaborative articles, 74 (66%) involved contributions by the USA. With regards to the non-collaborative articles, 596 articles (78%) were published by the USA. It should be noted that, 13 countries: Israel, Finland, Belgium, Brazil, Ireland, Argentina, Austria, South Africa, Taiwan, Iran, New Zealand, Singapore, and Portugal did not publish any single country articles, while China published only one single country article. Highly cited articles usually originated from a small field, centered in a few countries. Furthermore, the top 100 highly cited articles in health care sciences and services field were published

by ten countries including USA (81 articles), Canada (16), the UK (11), Netherlands (6), Switzerland (2), and one article for each of Sweden, Italy, Finland, Spain, and Singapore, respectively.

3.4. Citation Life Cycles of Articles with the Highest *TC2012*

The advantage of *TC2012* and *C2012* is that they are invariable and ensure repeatability in comparison to the index of citation from Web of Science [20]. In recent years, top *TC2012* [23] and *C2012* [19] articles were studied by the citation life. The articles with the highest *TC2012* can be considered the most popular articles in the research field. Article life shows impact history of articles [19]. The citation lives of the top ten highly cited articles (*TC2012* > 100) are shown in ▶Figure 4. Seven of the top cited articles were published in the 1990s, two in the 2000s, and one in 1981. Seven articles were published in *Medical Care*. Nine articles were contributed by the US while the UK published only one article in top ten *TC2012*. Again the highly cited article, entitled "The MOS 36-Item short-form health survey (SF-36). I. Conceptual-framework and item selection" [35], received the most citations (*TC2012* = 12,380), significantly more than the second article (*TC2012* = 4007). J.E. Ware and C.D. Sherbourne at New England Medical Center Hospital of USA published it in *Medical Care*. Articles by Ware et al. [36],

Kroenke et al. [38], and Elixhauser et al. [39] showed continually increasing citation rates in most years since publication. Conversely the other authors' citation rates climbed initially then plateaued and then remained steady for some years. In addition, J.E. Ware published four of the top ten articles including two first and two corresponding author articles.

Application of SF-36 has been increased and populated since its publication (▶Figure 4). The MOS SF-36 was a measure for surveying eight-dimension health status in the medical outcomes study, aimed to assess limitations in physical activities, social activities, usual role activities, and also mental health, pain and general health perceptions. Ware and his team also compared the 20-item short-form, 12-item short-form surveys, and tend to modify this assessment more convenient for application [35, 36]. The MOS series offered validate appraisal of health status and different versions for various situations, which made this approach worldwide adapted.

3.5 Citation Life Cycle of Articles with the Highest *C2012*

Article life shows the characteristics of an article's impact after publication. Top citations in recent year were studied to gain more details about the impact of the top cited articles [23, 25]. In the HCSS field, 53% of all highly cited articles had no citations (*C0* = 0), 21% articles had one

Country	Rank (*TP*)	Rank (*IP*)	Rank (*CP*)	Rank (*FP*)	Rank (*RP*)	Rank (*SP*)
USA	1 (670)	1 (596)	1 (74)	1 (636)	1 (601)	1 (62)
Canada	2 (118)	2 (64)	2 (54)	2 (85)	2 (72)	3 (8)
UK	3 (101)	3 (54)	3 (47)	3 (72)	2 (72)	2 (12)
Netherlands	4 (44)	4 (22)	4 (22)	4 (31)	4 (30)	4 (7)
Germany	5 (19)	5 (9)	9 (10)	5 (11)	5 (11)	5 (2)
Sweden	6 (18)	7 (5)	5 (13)	7 (6)	6 (6)	7 (1)
Australia	7 (17)	6 (6)	7 (11)	6 (9)	6 (6)	N/A
Switzerland	8 (14)	8 (2)	6 (12)	10 (4)	10 (4)	7 (1)
Italy	9 (13)	8 (2)	7 (11)	7 (6)	6 (6)	N/A
Spain	10 (9)	11 (1)	10 (8)	11 (3)	11 (3)	N/A

Table 4
Characteristics of top ten contributing countries

TP: total number of included highly cited articles; *IP*: number of included single country articles; *CP*: number of included internationally collaborative articles; *FP*: number of included first author articles; *RP*: number of included corresponding author articles; *SP*: number of included single author articles; N/A: not available
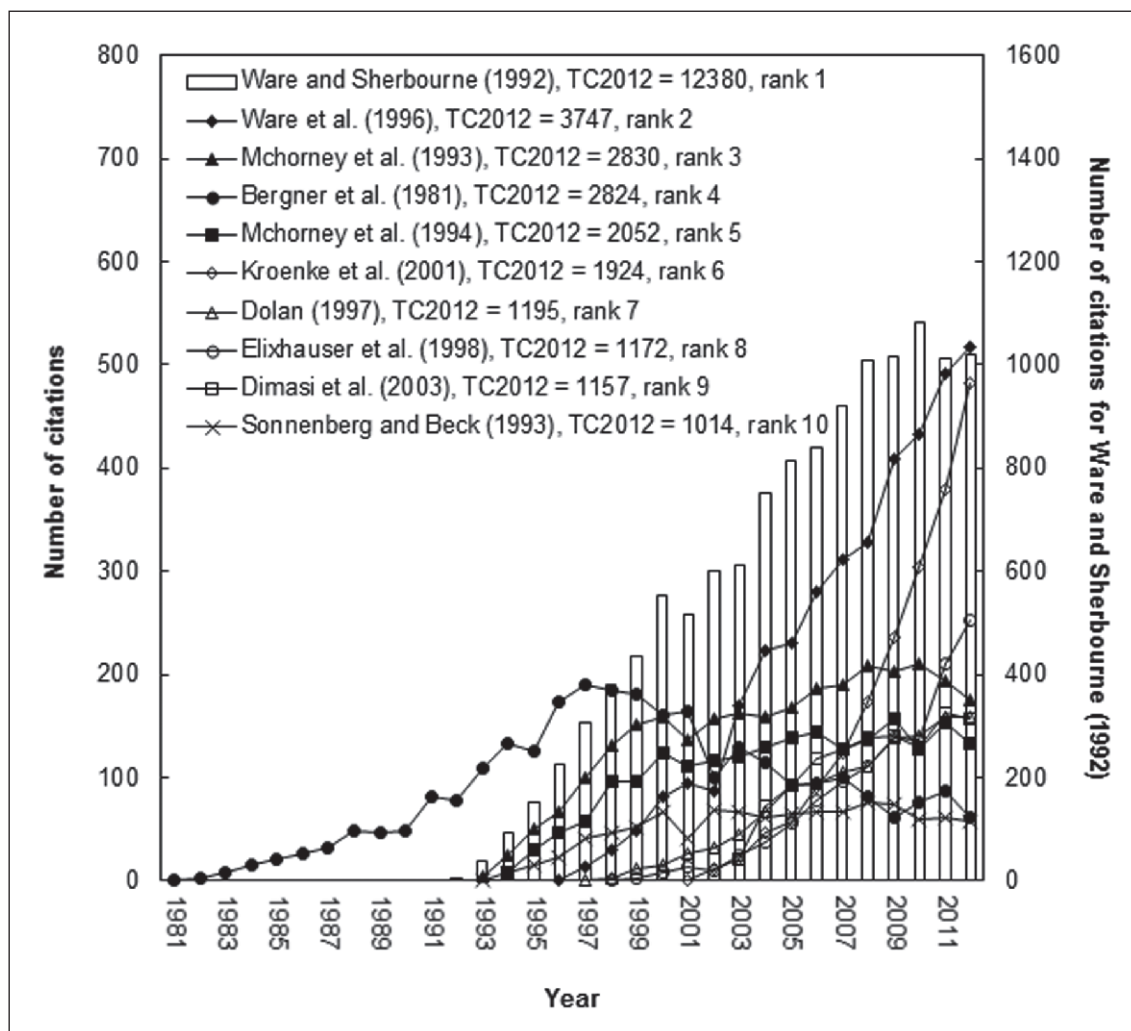
Figure 4
Citation life cycles of the top ten articles ($TC2012 \geq 1,000$)

citation ($C0 = 1$), and 10% articles had two citations ($C0 = 2$) during their first year of publication. $TC2012$, an accumulative number, may reach a large value as long as the time span is long enough. An article impact might not be always high [20]. Although some recently published within the past few years had great potential, they did not have a high $TC2012$. Of all the highly cited articles, 2.2% had no citations in 2012 ($C2012 = 0$), 3.3% articles had one citation in 2012 ($C2012 = 1$), and 3.5% articles have two citations in 2012 ($C2012 = 2$). Highly cited articles did not receive great citations all the time. Thus it would be interesting to investigate new publications that have shown high impact in 2012. The top 11 highly cited articles ($C2012 > 150$) in health care sciences and services field was examined (►Figure 5). All articles had influential increased trends after their publi-

cations. An early article titled "Concurrent and predictive-validity of a self-reported measure of medication adherence" [40] had citations less than ten times after its publication in 1986 for 11 years and then increased to 161 times in 2012. Among them, nine articles were published in *Medical Care* and one in *Journal of General Internal Medicine* and *Journal of Health Economics* respectively. The article by Quan et al. [41] is the only article with ten authors. Article "The PHQ-9: Validity of a brief depression severity measure" by Kroenke et al. [38] had high proportion in citations especially in recent years. Overall, it appeared to be going strong and showed no sign of leveling off. Except Bergner et al. [42] and Sonnenberg and Beck [43], all articles could be found in both ►Figure 4 and ►Figure 5 with $TC2012 > 1,000$ and $C2012 > 150$. There is a significant relation

between top cited articles with $TC2012$ and $C2012$.

3.6 Publication Characteristics of Authors

Both first author and corresponding author play significant roles in producing a paper. A total of 890 highly cited articles by 2,674 authors including 657 first authors and 646 corresponding authors, in health care sciences and services field were analyzed. Only 613 (23% of the 2,674) authors had both first author and corresponding author articles. Ten of 613 authors had $h > 0.7854$ and two authors had $h < 0.7854$, while 601 (98% of the 613) authors had the same numbers of first author and corresponding author articles. Percentage of author published highly cited articles with $h = 0.7854$ in health care sciences and services field

was found to be much higher than authors published in the top-cited articles in the SCI-EXPANDED [25] and chemical engineering field [23]. However, such high percentage of author published highly cited articles was reported in social science field [44]. ►Figure 6 displays the distribution of the top 107 authors with $j \geq 4$, ($j \ Cos \ h$ and $j \ Sin \ h$ are chosen as the x and y coordinate axes). Each dot represents one value that could be one author or many authors when they had the same publication intensity and characteristics. The authors who contributed the most highly cited articles were J. E. Ware ($j = 14$), followed by S. M. Shortell with $j = 10$. Publication characteristics constant, h, could help to obtain the different proportion of corresponding author articles to first author articles. It is very helpful especially when j of authors is the same to distinguish the different performance of

authors. For example, the j of D. W. Bates, C. N. Klabunde, D. W. Baker, D. A. Revicki, E. J. Thomas, H. G. Schmidt, L. H. Aiken, A. M. O'Connor, K. W. Eva, A.B. Flood, R. M. Harden, J. H. Hibbard, and M. Bergner were all the same of 6. However h of Bates was 1.107 but h of others was 0.7854. That means Bates had greater proportion of corresponding author articles to first author articles than others. Within these 107 authors, only four authors with $h > 0.7854$, including D. W. Bates ($h = 1.107$), L. A. Cooper ($h = 0.9828$), C. M. Callahan ($h = 0.9828$) and D. Cella ($h = 0.9273$). These authors had more corresponding author articles than first author articles, indicating that top cited authors contributing to the highly cited articles were more likely to be designated as the corresponding authors. K. R. Lorig ($h = 0.5880$) was the only one who had more first author articles than

corresponding author articles. Other 102 authors just on the boundary line ($h = 0.7854$) having the same quantity first authors articles and corresponding author articles.

4. Discussion

4.1 Publication Year

Similar result in lack of recent highly cited articles in HCSS field could be also found in the top-cited articles in chemical engineering in SCI-EXPANDED [23] and social work in Social Science Citation Index (SSCI) [44]. The earliest papers in HCSS category could be found in 1964. There were 244 articles in HCSS category from 1964 to 1971. Only 5,466 (6.7%) articles were published in 1960s, 1970s, and 1980s, while articles in 1990s-2010s accounted for
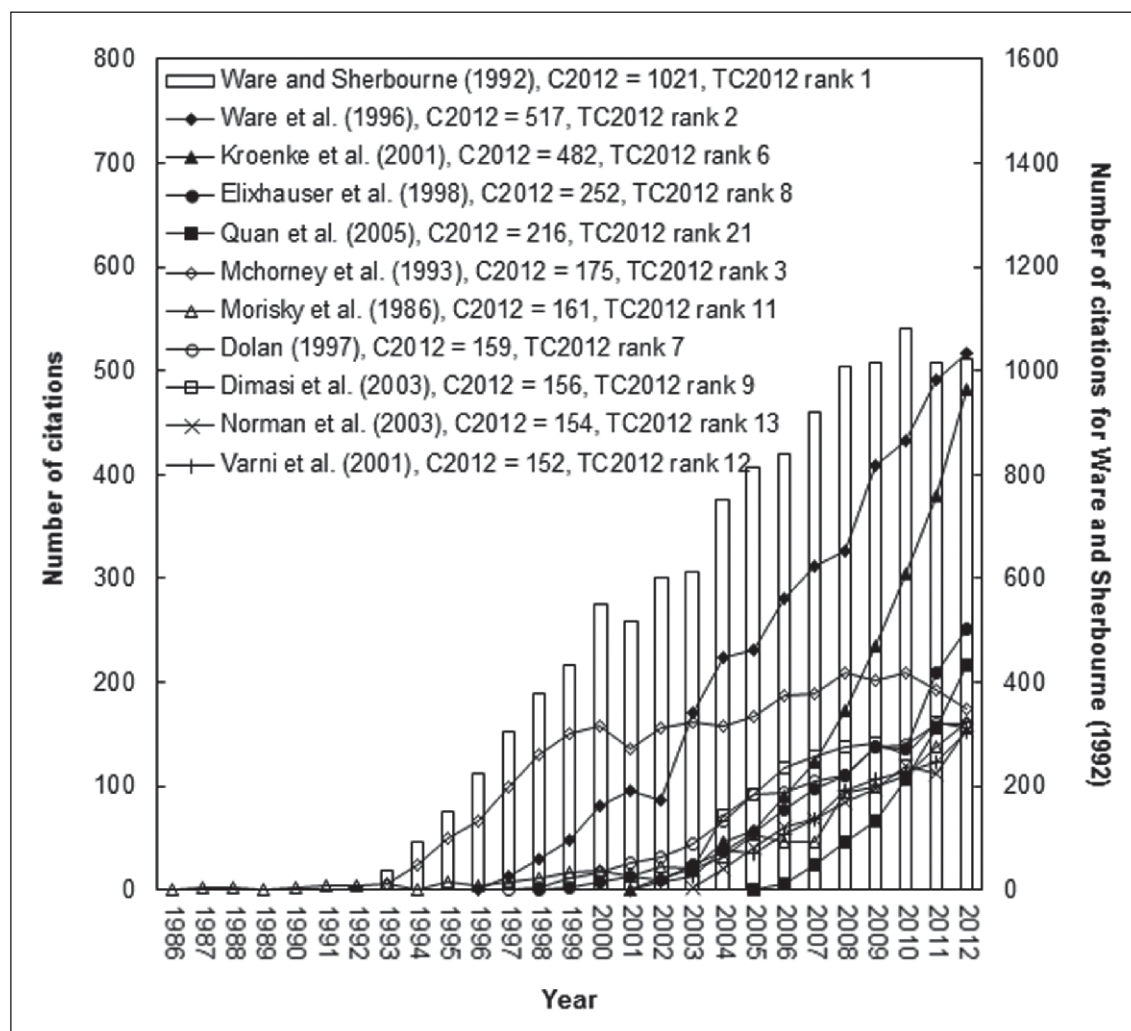

Figure 5
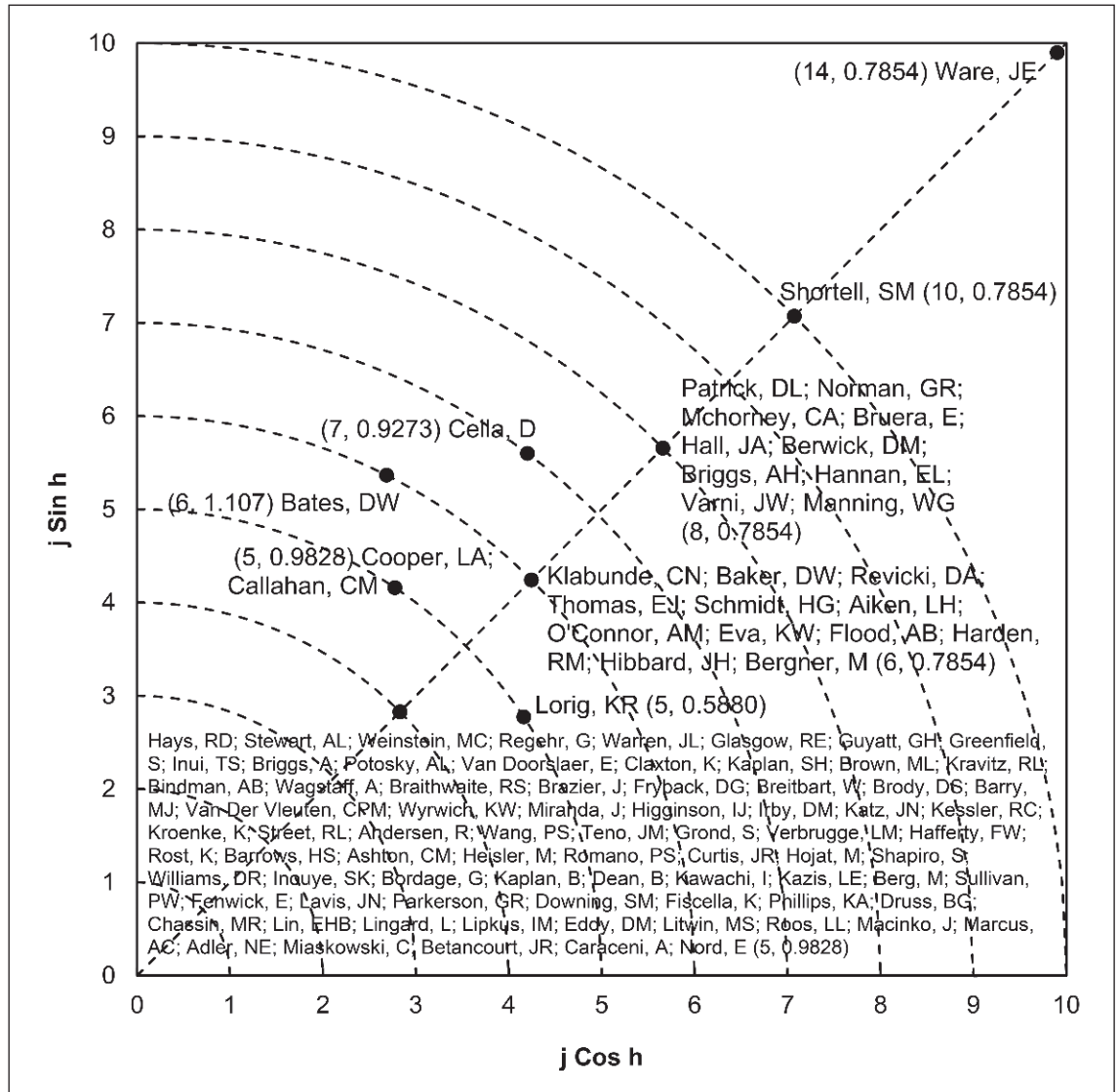Citation life cycles of the top 11 articles ($C2012 \geq 150$)

Figure 6
Top 107 authors with Y-index ($j \geq 4$)

the major part (93%). One possible reason for there being no highly cited articles before 1977 might be the low production during 1960s–1980s. Various studies show that highly cited articles reach its citation peak in the first several years after publication. For example 3–7 years for clinical physiology and nuclear medicine research fields [45]; 6 years of 152 journals [22]; 4–5 years for the scientific production of Norway [21]; 5 years for ocean circulation [46]. The low production during 1960s–1980s meant less opportunity for articles to become highly cited. Furthermore, it seems that with increasing time since publication there is a more chance of the paper being forgotten [8]. As time passes, previously highly cited articles are gradually less often

cited, probably because the phenomenon "Obliteration by Incorporation" occurred [48], which means "the obliteration of the sources of ideas, methods, or findings by their being anonymously incorporated in current canonical knowledge" [49]. It is also accepted that newly published articles require time to accumulate citations [8]. To cite the original paper would be appropriate, it not only respects authors who presented a novel idea in research but also facilitates colleagues to read the original work to better understand the idea in detail [50] The mean number of *CPP* 699 by the top 100 articles was higher than the value of 100 classic citations in some medical fields, for example 283 in anesthetic journals [51], 318 in ophthalmology journals

[11], 405 in general surgical journals [52], 447 in orthopaedic surgery [53], and 629 in urology [54].

4.2 Journal

The value of number of journals (23) in HCSS field for top 200 highly cited articles was greater than other medical fields, for example, seven journals in the top 100 from classic papers of orthopaedic surgery [53], ten journals in the top 100, from general surgical citations classics [52], eleven journals in the top 100 cited articles in obstetrics and gynecology [18], 13 journals in 100 from ophthalmology class citations [11], and 15 journals in the top 100 cited articles, from urology [54]. The highly

cited articles were published not only in high impact factors as expected, but also in low impact factors. The two performances were discussed by previous studies. The highly cited articles published in journals with high impact factors were also found in the subject area of anesthetics [51]. The leading journals attracted the classic publications, which in turn maintained the high impact factor of these journals [55]. However, highly cited articles could also be always found in journals with low impact factor [25].

4.3 Authors, Institutions, and Countries

Inter-institutional collaboration rate (60%) was significantly higher when compared to some medical fields. For example only 12% of 100 top-cited articles in general surgical journals were inter-institutional collaborations [52] and 8% of 100 ophthalmology class citations were inter-institutional [11]. However, the percentage of collaboration in the highly cited articles (13%) was similar to some other areas in SCI-EXPANDED, such as 10% in chemical engineering [23], and 14% adsorption research field [20]. In general, collaboration played an important role in enhancing the impact of articles [56, 57]. The highly cited papers typically involve more collaborative research than the general norm [21]. However, higher percentage of single country's highly cited articles (87%) was found in health care sciences and services field. The high percentage of singly country articles was similar to science [20], engineering [23], and social work fields [44]. Domination in highly cited articles by the USA was not surprising since this pattern occurs in other scientific fields such as, stem cells [58], obstetrics and gynecology [18], and orthopaedic surgery [53]. The top cited publications originated from USA are explained in part by the large number of the American scientific publications [59]. There is some evidence that USA authors tend to reference articles from USA journals than from other countries [60]. Furthermore, the most highly cited articles originated from only a small number of countries. Other disciplines show the same trend with, the 100 top-cited articles in

General Surgical journals were produced by 6 countries [52]; top 100 most frequently cited articles in Anesthetic journals originated from 9 countries [51]; the top 100 ophthalmology classic citation articles originated from 10 countries [11].

4.4 Study Limitations

This study focused on the highly cited articles in the Web of Science category of Health Care Sciences & Services according to the citation index from SCI-EXPANDED. An investigation of ecology journals on Web of Science revealed a citation error rate of 41% [61]. It is known that different specialities have different citation rates, the same specialities in different countries have different citation rates [62]. Size of audience, which also needed to be noticed for citation analysis to work, influenced the probability of being cited and then the potential citing audience for all papers [63], such as disciplines difference (Hyland, 1999). It has been investigated that the computer scientists more often used citations to direct their audience to further reading, whereas the sociologists' texts featured more cases of critical citations [64]. There are some traditional non-citing areas of research that simply do not get cited, even though the work is used [65].

The high citations of one publication could be reached by various citation functions and citer motivations. Garfield [66] stated that reference citations are provided in papers for numerous reasons including, among others: 1) Paying homage to pioneers; 2) Giving credit for related work (homage to peers); 3) Identifying methodology, equipment, etc. 4) Providing background reading; 5) Correcting one's own work; 6) Correcting the work of others; 7) Criticizing previous work; 8) Substantiating claims; 9) Alerting to forthcoming work; 10) Providing leads to poorly disseminated, poorly indexed, or uncited work; 11) Authenticating data and classes of fact – physical constants, etc.; 12) Identifying original publications in which an idea or concept was discussed; 13) Identifying original publication or other work describing an eponymic concept or term as, e.g., Hodgkin's Disease, Pareto's Law, Frie-

del-Crafts Reaction, etc.; 14) Disclaiming work or ideas of others (negative claims) 15) Disputing priority claims of others (negative homage). Operational citations usually occurred not only when a concept or theory is referred to as a tool to substantial the author's claim, but also when mathematical or physical techniques, results, references, or conclusions are borrowed from the cited paper [67]. Not all the citations meant the importance of cited work, such as disclaiming work or ideas of others, and disputing priority claims of others. In addition, "Obliteration by Incorporation" which could influence citations more likely occurs for the previously highly cited articles and elite scientist [48]. These factors could limited citations as an as a measure of impact.

In addition, a potential bias in analysis of authorship might occur when different authors have the same name or authors used different names over time in their articles. Another potential confounder arises when an author moves from one affiliation to another. One possibility to establish an unambiguous association of each author with his/her articles would be to create an "international publication identity number" that is assigned to each author on the publication of his/her first paper in a Web of Science-listed journal [68].

4. Conclusions

During the period from 1958 to 2012, 890 highly cited articles were published in 49 journals covered in health care sciences and services field in Science Citation Index EXPANDED from 28 countries. More than a half of the total highly cited articles in health care sciences and services field were published in *Medical Care* and *Journal of General Internal Medicine*. Eighty-seven percent of the highly cited articles were single country publications. US produced the most independent, collaborative, first author, corresponding author, and single author articles, followed by Canada and the UK. A significant relation was observed between articles between the highest *TC2012* and *C2012*. Information from citation life cycles of articles with the highest *TC2012* and *C2012* gives more details

about impact history of the highly cited articles. Harvard University contributes the most to the total, independent, collaborative, first author, and corresponding author articles. The evaluation by Y-index shows that J.E. Ware at New England Medical Center Hospital of USA made the greatest contribution to the highly cited articles in health care sciences and services field.

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