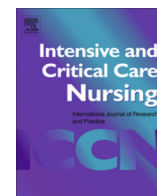




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Review article

The 100 top-cited systematic reviews/meta-analyses in central venous catheter research: A PRISMA-compliant systematic literature review and bibliometric analysis

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ABSTRACT

Objective: The central venous catheter is used extensively worldwide. The purpose of this bibliometric analysis was to identify the 100 top-cited systematic reviews/meta-analyses in the literature on central venous catheters and to capture the most important trends in this area of research.

Research methodology: A search was performed in the Web of Science Core Collection on studies published prior to November 12th, 2019. The search terms included central venous catheter, systematic review and meta-analysis. Retrieved studies were ranked by citation number and selected by two of the authors. Information such as citation number, author, institution, country and year of publication was collected.

Results: The 100 top-cited studies published between 1992 and 2017 were reviewed, with the largest proportion published in 2008 (n = 17). The number of citations ranged from 14 to 660. The country with the largest number of studies was the United States of America (n = 36). *Critical Care Medicine* published the greatest number of these studies (n = 13). The largest number of these studies were focused on central venous catheter-related infection (n = 56) and thrombosis (n = 19).

Conclusion: Developed countries were the most productive in the field of central venous catheters. Most meta-analyses focused on complications associated with central-venous catheters such as infection and thrombosis.

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Implications for clinical practice

- The majority of the 100 top-cited systematic reviews/meta-analyses on central venous catheters were performed in developed countries.
- Research on catheter-related bloodstream infection and thrombosis remain hot topics in clinical practice.
- Most systematic reviews/meta-analyses on central venous catheters were published in the journal of *Critical Care Medicine*, which may indicate that patients in intensive care units are the main target subjects.

Introduction

The central venous catheter (CVC) has been widely used worldwide for various indications, such as haemodialysis, delivering chemotherapy drugs and parenteral nutrition support (Jaffer et al., 2008; Pittiruti et al., 2009; Verso and Agnelli, 2003). In the

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United States of America (USA), nearly 15 million CVCs are used annually (Beheshti, 2011). Although CVCs are widely applied, they still lead to a series of complications when cannulating or during retention. There are many original studies focused on identifying risk factors for catheter-related complications (e.g., catheter-related infection, thrombosis, occlusion and phlebitis) (Chopra et al., 2014; Raad et al., 1997; Yu et al., 2018) and exploring ways to reduce and prevent catheter-related complications stemming from catheterisation, indwelling, and removal (Arvaniti, 2017; Gilbert et al., 2016; Parienti et al., 2015; Raad et al., 1997; Velasquez Reyes et al., 2017). However, due to a large number of original studies, the results of these might be inconclusive, and it may be increasingly difficult for clinical personnel to find the best evidence to guide their clinical practice.

Systematic reviews/meta-analyses aim to evaluate, select and synthesize high-quality original studies relevant to a specific question to provide more precise and frequently updated results (Zhang et al., 2017). The strength of evidence from these is generally superior to single original studies. To date, there have been many systematic reviews/meta-analyses concentrating on the field of CVCs that have been published (Blot et al., 2014; Hind et al., 2003; Veenstra et al., 1999), these studies have promoted the treatment of patients and the development of intravascular therapy. However, it is precisely because there are so many studies that the risk of failing to capture critical information has been increased for followers of this field.

Number of citations is commonly adopted to assess the academic influence of a study. Bibliometric citation analysis has been utilised widely to evaluate the academic development of a specific specialty (Jiang et al., 2019). There are many journals that have published studies on bibliometric citations analysis in the fields of cancer (Hachem et al., 2017), orthopaedics (Jiang et al., 2019), tuberculosis (Zhang et al., 2017), diabetes (Zhao et al., 2016), neuroscience (Park et al., 2017) and radiology (Dolan et al., 2015). However, as of now, we have found no bibliometric citation analyses in the field of CVC in the electronic database. Therefore, the purpose of this study was to identify and analyse the 100 top-cited systematic reviews/meta-analyses in the field of CVC and to capture the most important trends in the research on CVCs.

Materials and methods

This study was exempt from institutional ethics committee review as it was a bibliometric analysis. This study was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (Zhang et al., 2017).

Study search

To identify the 100 top-cited systematic review/meta-analysis studies in the field of CVCs, we performed a search of the Web of Science Core Collection on November 12th, 2019. The search strategy was as follows: "central venous catheterization" OR "central line*" OR "central venous catheter*" OR "central vein catheter*" OR "central venous cannulation" OR "central venous access device*" OR "peripherally inserted central catheter*" OR "femoral venous catheter*" and "systematic review" OR "meta-analysis". The search results were ranked by the number of citations, and the 100 top-cited studies were identified according to the number of citations.

Inclusion and exclusion criteria

We included all studies that were systematic reviews or meta-analyses pertaining to CVCs. We excluded studies that were correc-

tions of previous studies and studies that only mentioned terms related to CVCs but did not concentrate on CVCs. Studies involving both CVCs and other types of intravascular catheters were also included.

Data extraction and analysis

Two authors independently performed data collection. Any discrepancy was resolved by discussion or decided upon by a third reviewer. The following information was collected: number of total citations, number of citations in 2019, average citations per year, first author's name, corresponding author's name, corresponding author's institution and country, journal, publication year, number of pages, and number of references. If a corresponding author had more than one institution, the first institution was selected for analysis.

Results

Basic characteristics of the included studies

The main characteristics of the 100 top-cited studies are shown in Supplementary Table 1. The number of citations of the 100 top-cited studies varied from 14 to 660 (median, 50.5), with a total citation count of 8505. The numbers of citations in 2019 were between 0 and 47 (median, 3). Since their publication, the average citations per year ranged from 1.25 to 52 (median, 5). The rankings, based on the average citations each year, are also listed in Supplementary Table 1. The numbers of pages in the included studies ranged from 1 to 80, with an average of 11 pages. The number of references in the included studies ranged from 8 to 355, with an average of 57 references.

The most cited study, with a total of 660 citations, was titled "The risk of bloodstream infection in adults with different intravascular devices: A systematic review of 200 published prospective studies", and was published in 2006 by Maki et al. in the *Journal of Mayo Clinic Proceedings* (Maki et al., 2006). Its average number of citations per year and citations in 2019 also ranked first at 52 and 47 respectively. The second most cited study was a meta-analysis comparing the clinical effectiveness of ultrasound to anatomic landmark method for guiding central venous cannulation, published in the *British Medical Journal* in 2003 (Hind et al., 2003). The third study was similar to the second study but was published in 1996 in *Critical Care Medicine* (Randolph et al., 1996).

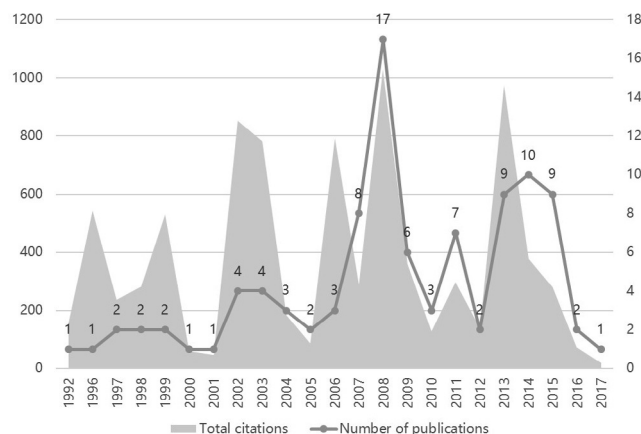


Fig. 1. Number of 100 top-cited studies and the total number of citations per year.

Distribution of years of publication

The 100 top-cited systematic reviews/meta-analyses were published between 1992 and 2017 (Fig. 1). The earliest study, titled "Transparent polyurethane film as an intravenous catheter dressing. A meta-analysis of the infection risks", was published by Hoffmann et al. in the *Journal of the American Medical Association*. The year with the most studies was 2008, with 17 studies, followed by 2014, 2013 and 2015, with 10, 9 and 9 studies, respectively. The year with the most citations was also 2008, with 1029 citations, followed by 2013 and 2002, with 975 and 854 citations, differently.

Distribution of authors

Most of the studies (n = 75) had between two and six authors, studies with four authors were the most common (n = 24). Eight researchers were the corresponding author for more than one study among the 100 top-cited articles (Table 1), of which Safdar had the most (n = 5). Eleven authors had more than one study as the first author, of which Randolph had the most (n = 3).

Distribution of countries

The 100 top-cited studies came from 20 countries (Argentina, Australia, Belgium, Brazil, Canada, China, England, France, Germany, Greece, Ireland, Israel, Italy, Japan, Netherlands, Scotland, Spain, Sweden, Switzerland, USA). Eleven countries had more than two top-cited studies (Fig. 2). The USA had the most top-cited studies (n = 36), followed by Canada (n = 14), England (n = 8), and Australia (n = 8). Consequently, the country with the most citations was also the USA with 4126 citations, followed by England and Canada with 1102 and 993 citations, respectively.

Distribution of published journals

The 100 top-cited studies were published in both comprehensive and specialized periodicals (Table 2). The journal with the largest number of included studies was *Critical Care Medicine* (n = 13), followed by the *Cochrane Database of Systematic Reviews* (n = 5), and *Clinical Infectious Diseases* (n = 5). *Critical Care Medicine* had

Table 1
Authors with more than one study as the corresponding or first author.

Author	Name	Number of studies	Country
Corresponding author	Safdar, N	5	USA
	Randolph, AG	3	USA
	Veenstra, DL	3	USA
	Akl, EA	2	USA
	Maki, DG	2	USA
	Niel-Weise, BS	2	Netherlands
	Rabindranath, KS	2	England
	Ullman, AJ	2	Australia
First author	Randolph, AG	3	USA
	Akl, EA	2	USA
	Chopra, V	2	USA
	Maki, DG	2	USA
	Niel-Weise, BS	2	Netherlands
	Rabindranath, KS	2	England
	Ramritu, P	2	Australia
	Safdar, N	2	USA
	Ullman, AJ	2	Australia
	Veenstra, DL	2	USA
	Hockenhull, JC	2	England

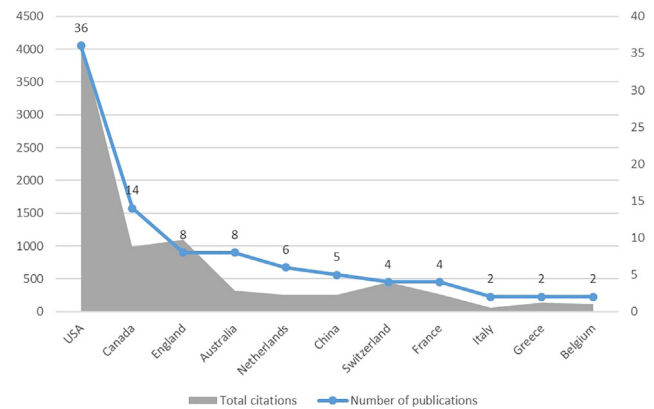


Fig. 2. Countries with at least two of the 100 top-cited studies (based on the country of the corresponding author).

the most citations, followed by *Journal of the American Medical Association* and *Annals of Internal Medicine*.

Distribution of topics

Among the 100 top-cited systematic reviews/meta-analyses, 56 studies pertained to catheter-related bloodstream infection (CRBSI), with a total of 4782 citations, followed by catheter-related thrombosis (n = 19), with a total of 1263 citations and occlusion (n = 5), with a total of 199 citations.

Discussion

Bibliometric analyses enable readers to gain insight into the history and development of a specific specialty (Chen et al., 2019). Identifying the classic citations could help us catch the emerging themes and future trends for a particular discipline. From 1929 to the present, the field of CVC has been developing for nearly ninety years (Beheshti, 2011), but we did not find any bibliometric analyses in the field of CVC. As systematic reviews/analyses always aim to synthesise data of the latest, high-quality original studies that are similar to provide more reliable results and are always regularly updated, we performed this study to identify the 100 top-cited CVC systematic reviews/meta-analyses and to analyse the main characteristics of them.

The number of citations for the 100 top-cited studies varied significantly from 14 to 660, and only the top 21 studies had more than 100 citations, which suggests that the popularization of systematic reviews/meta-analyses needs to be further promoted. These studies were published from 1992 to 2017, mainly published in 2008, which is consistent with the development of the methods of systematic review/meta-analyses.

Over one third of the included studies were from the USA. CVC was originated by a German surgical resident named Werner Forssmann in 1929, but was prosperously developed in the USA. In 1956, Forssmann and two other researchers received the Noble Prize in Medicine for their achievements in CVC (Beheshti, 2011). The American Infusion Nurse Society (INS) established in 1973 and American Association for Vascular Access (AVA) founded in 1985 are two of the earliest and most authoritative organisations for globalization in the practice of infusion therapy (Gorski et al., 2016). This tracks closely with the impact and scientific output of the USA in the field of intravascular therapy. We found only seven studies that were from developing countries (China, Brazil, and Argentina) (Chen et al., 2014; Liu et al., 2013; Maki et al., 2011; Tuon et al., 2007; Wang et al., 2010; Wu et al., 2013; Zhao et al., 2014). This might be due to the high cost of placement of

Table 2
Journals with no less than 2 of the 100 top-cited studies.

Journals (Abbreviations)	Impact factor (2018)	5-year impact factor	Number of studies	Total Citations	Average citation/study
<i>Crit Care Med</i>	6.971	7.514	13	1615	124
<i>Cochrane Db Syst Rev</i>	7.755	7.949	5	157	31
<i>Clin Infect Dis</i>	9.055	8.835	5	412	82
<i>J Thromb Haemost</i>	4.662	5.394	4	238	60
<i>Am J Kidney Dis</i>	6.653	7.065	3	217	72
<i>Infect Control Hosp Ep</i>	2.856	3.391	3	220	73
<i>JAMA</i>	51.273	46.312	3	686	229
<i>J Adv Nurs</i>	2.376	3.01	3	127	42
<i>J Hosp Infect</i>	3.704	3.345	3	128	43
<i>J Vasc Access</i>	1.397	1.363	3	61	20
<i>Am J Infect Control</i>	1.971	2.127	2	123	62
<i>Am J Med</i>	4.76	5.412	2	59	31
<i>Ann Intern Med</i>	19.315	19.676	2	443	222
<i>Infection</i>	2.927	2.52	2	74	37
<i>J Crit Care</i>	2.783	2.92	2	144	72
<i>J Thromb Thrombolys</i>	2.941	2.213	2	62	31
<i>Lancet Infect Dis</i>	27.516	23.363	2	153	77

CVC and the requirement for advanced technical support during catheterization and retention or related to the delayed popularity of meta-analysis as scientific approach in these countries.

In this study, nearly all included meta-analyses are focused on potential complications associated with the use of CVCs, especially Catheter Related Blood Stream Infection (CRBSI) and thrombosis. CRBSI is one of the most frequent and devastating complications of CVCs, which could increase the costs of hospitalisation, length of stay and mortality (Nuckols et al., 2016; O'Grady et al., 2011; Siempos et al., 2009). Scholars are exploring various interventions, such as closed infusion containers, aseptic skin preparation, and CVC bundles, to reduce the occurrence of CRBSI. Therefore, there are many original studies and systematic reviews performed on them. A systematic review performed by Velasquez Reyes DC et al. found that closed infusion systems, the aseptic technique used during CVC insertions and retention, prompt removal of unnecessary CVCs and appropriate insertion site selection could reduce the occurrence of CRBSI (Velasquez Reyes et al., 2017). Another systematic review also revealed that some quality improvement interventions (e.g., insertion checklists, providers education, sterile dressings and antimicrobial catheters) which were strongly recommended by the Agency for Healthcare Research and Quality (AHRQ) were associated with a 57% reduction in CRBSI (IRR 0.43, 95% CI 0.35-0.51) and net saving of about \$2 million for each hospital over a three-year period (Nuckols et al., 2016). As research regarding the development of intra-vascular catheter-associated infection continues, more meta-analyses focused on aspects of infection can be expected in the upcoming years (Pivkina et al., 2018).

Thrombosis is another frequent and severe complication of CVCs, which could result in secondary complications like CRBSI, pulmonary embolism and post-thrombotic syndrome (Baskin et al., 2009; Jones et al., 2019). Previous studies demonstrated that the incidence of CVC-related symptomatic and asymptomatic thrombosis ranged from 0.3% to 14.9% and 6.30% to 64.50% respectively, depending on the populations, use of prophylactic interventions and diagnostic methods (Baskin et al., 2009; Bottino et al., 1979; Chopra et al., 2013; Jones et al., 2019; Worley et al., 2007). Peripherally inserted central catheters (PICCs) were associated with a higher risk of thrombosis compared with other types of CVCs (OR 2.55, 95%CI 1.54-4.23), particularly in patients with cancer or who were critically ill (Chopra et al., 2013).

Nowadays, many methods that have been confirmed to be useful to reduce thrombosis, such as preventing CRBSI, locating the catheter tip in central veins, selecting veins with the diameter ratio of PICC to vessel less than 45% and avoiding the CVC placed from

lower extremities (Baskin et al., 2009; Chen et al., 2020; Chopra et al., 2013). On the other hand, there is still controversy about the use of anticoagulation to treat asymptomatic thrombosis. The American College of Chest Physicians guidelines recommended the treatment of thrombosis with low-molecular-weight heparin for 6 to 12 weeks, but the strength of this evidence is low (Grade 2C) (Monagle et al., 2012). A more recent study, following the untreated patients with asymptomatic thrombosis for two years, challenges this recommendation because no significant acute or long-term sequelae of asymptomatic thrombosis happened (Jones et al., 2019).

In addition to CRBSI and thrombosis, there are systematic reviews performed on other CVC-related complications, such as occlusion, phlebitis, mechanical complications and misplacement (Chen et al., 2020; Lopez-Briz et al., 2014; Smit et al., 2018). Accidental removal of CVCs is another complication (Galazzi et al., 2019), but no systematic review covered it.

Limitations

This study has several limitations. First, we only included studies from the Web of Science Core Collection, so there may be some that we were missed. Thus, the results of this study should be carefully interpreted. Second, many factors may affect the number of citations for a given study, such as number of years since publication, journal of publication, original language, institution and the reputation of the author. Furthermore, we did not analyse self-citations and citations in lectures and textbooks; nor did we account for the fact that some authors might be inclined to cite the studies from the specific journal in which they intend to publish a study (Zhao et al., 2016). Third, we only extracted information about the first author and corresponding author. It is possible that some studies might have co-first authors or co-corresponding authors. However, they were not represented in this study, and we did not analyse the information about them. Last, when we analysed the distribution of the originating institutions and countries, we based this information only on the institution address of the corresponding author. Once the corresponding author's address changed, there might be a statistical bias (Zhang et al., 2017). Additionally, for corresponding authors who work in more than one institution, we only considered the first institution.

Conclusion

In conclusion, this study is the first bibliometric study to identify the 100 top-cited systematic reviews/meta-analyses in the

field of CVC. This study analyses the main characteristics of the most cited studies and the results suggested that 1) they were mainly from the USA, Canada, England, Australia and other developed countries, 2) they were predominantly published in journals related to critical care and infection, and 3) Most meta-analyses focused on complications associated with central-venous catheters such as infection and thrombosis. Since systematic reviews/meta-analyses always synthesise and analyse a series of similar and latest original studies, we analysed the most-cited systematic reviews/meta-analyses that might have a stronger impact on future clinical practice and research work.

Authors' contributions

Study concept and design: Zuoyan Liu, Manuscript draft: Zhaojing Huang, Search strategy development: Zhaojing Huang, Hongxiu Chen, Data extraction and analysis: Zhaojing Huang, Hongxiu Chen, Final approval of the manuscript: All authors.

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Ethics approval

Not applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.iccn.2020.102803>.

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