Advancing emergency care: A 20-year bibliometric analysis of prehospital airway suction research

Ardian Jafar A. Hukum*, **Sidik Awaludin**

Departement of Nursing, Faculty of Health Science, Jenderal Soedirman University, Indonesia

Abstract

Background: Prehospital airway suction is a critical intervention for maintaining airway patency in emergencies, especially in trauma, cardiac arrest, or airway obstruction. Despite its clinical significance, research on its effectiveness, device innovation, and procedural outcomes remains underrepresented compared to other airway management practices.
Purpose: This study systematically maps the scientific landscape, research trends, and thematic structures of prehospital airway suction, identifying clusters, gaps, and future directions.
Methods: A bibliometric analysis was conducted using Publish or Perish to retrieve articles from Scopus and PubMed (2005–2025) with the keyword "prehospital airway suction." Data were analysed using VOSviewer for co-occurrence of terms in titles and abstracts, producing network, overlay, and density visualisations.
Results: From 90 relevant publications, 71 (78.89%) directly addressed prehospital airway suction. Five thematic clusters emerged: (1) airway devices and preparation, (2) healthcare providers and prehospital procedures, (3) suction effectiveness and safety, (4) advanced techniques such as Suction-Assisted Laryngoscopy and Airway Decontamination (SALAD), and (5) clinical outcomes and evaluations. Overlay visualisation revealed a recent research shift (2020–2025) toward portable device innovation, advanced suction methods, and simulation-based training. The most cited work was Prekker et al. (2014), cited 79 times.
Conclusion: This first bibliometric study on prehospital airway suction highlights priorities in procedural standardisation, portable and efficient device development, effective suction techniques, and enhanced simulation-based training. The findings offer a reference for future research targeting specific populations, extreme emergencies, and the integration of emerging technologies.

Keywords: airway suction; bibliometric analysis; portable suction; prehospital; SALAD technique

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Corresponding author

Ardian Jafar A. Hukum*
Departement of Nursing, Faculty of Health Science, Jenderal Soedirman University, Indonesia; Address: Jl. Dr. Soeparno, Karangwangkal, Karang Bawang, Grendeng, Kec. Purwokerto Utara, Purwokerto, Jawa Tengah, 53122. Indonesia ; Phone:+6282248047075; E-mail:ardianjafar.a.hukum@gmail.com

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Introduction

In the management of emergency patients, suction plays a vital role in maintaining a clear airway free from secretions and obstructions that may compromise oxygenation and ventilation (Carney et al., 2021). Given that airway compromise can rapidly lead to hypoxia, respiratory arrest, or even death, ensuring airway patency and function is a critical factor in supporting patient survival (Berkenbush et al., 2023; Jarvis et al., 2024). International guidelines and systematic research evidence underscore that prompt airway intervention significantly contributes to clinical outcomes, particularly in cases of severe trauma, out-of-hospital cardiac arrest, and other critical conditions (Gage, Powell, Bosson, et al., 2023; Jacobs & Grabinsky, 2014). One of the major challenges in the field is airway obstruction caused by blood, vomitus, or excessive secretions. In such situations, the use of suction devices becomes crucial to ensure airway patency and to prevent potentially life-threatening aspiration (Sontakke et al., 2023). Consequently, the demand for portable, efficient, and rapidly deployable suction equipment

has become a primary concern in the development of emergency medical technologies (Dunne et al., 2020; Gage, Powell, Nassal, et al., 2023; Kibblewhite et al., 2023).

Although airway suctioning has been incorporated into basic paramedic training, scientific literature that explores its effectiveness, associated risks, and technological advancements remains limited. Improper suctioning procedures may lead to complications such as hypoxia, mucosal injury, or exacerbation of aspiration (Brainard & Gerecht, 2015; Kibblewhite et al., 2023). Previous studies have largely focused on endotracheal intubation or advanced airway management, while basic suctioning as a fundamental intervention is often overlooked in systematic reviews (Warnock & Gates, 2023).

Given the increasing complexity of emergency cases and ongoing advancements in portable suction technology, it is imperative to conduct a comprehensive mapping of research trends and the scientific knowledge structure in this field. A bibliometric approach can reveal the relationships between topics, key researchers, institutions, and shifts in research focus over time (van Eck & Waltman, 2010; Zupic & Čater, 2014). Therefore, this study uses a bibliometric approach with the aim of identifying trends, main themes, and directions of research development regarding the use of airway suction in prehospital situation, so as to provide a comprehensive overview of scientific progress and opportunities for innovation in the future.

Materials and Methods

Design

This study adopts a quantitative bibliometric methodology to systematically examine prevailing research trends and thematic patterns, with the objective of identifying underrepresented areas that present potential for novelty in subsequent scholarly investigations (Donthu et al., 2021; Kumar et al., 2024; Öztürk et al., 2024).

Data Collection

The article search was conducted in July 2025 using two research databases: Scopus and PubMed. Two researchers independently performed the search using the Publish or Perish application. Differences of opinion between the two researchers were resolved through discussion. Discussions were conducted based on the inclusion and exclusion criteria agreed upon at the outset and their relevance to the study. The keyword used was prehospital airway suction. The keywords are applied to the title, abstract, and keywords. This is done to ensure that all publications discussing prehospital airway suction can be properly identified. Articles collected were limited to those published between 2005 and 2025. The inclusion criteria for this study were studies discussing prehospital airway suction. Meanwhile, the exclusion criteria were editorial articles, intrahospital suction, and surgical suction. The article collection process can be seen in the prisma diagram in Figure 1.

Data Analysis

The collected articles were subsequently analysed using the VOSviewer application. The process of entering data into the VOSviewer application is carried out by one researcher. VOSviewer is a software tool designed for analysing and visualising bibliometric data (van Eck & Waltman, 2010). Bibliometric visualisation was carried out using co-occurrence of terms in titles and abstracts (Donthu et al., 2021; Kumar et al., 2024) resulting in three distinct types of visualisation: network visualisation, overlay visualisation, and density visualisation (Donthu et al., 2021; Kumar et al., 2024; Öztürk et al., 2024; van Eck & Waltman, 2010). Density visualisation to illustrate term frequency, network visualisation to depict the interconnections between terms, and overlay visualisation to show temporal distribution (van Eck & Waltman, 2010). The minimum number of occurrences was set at five in order to capture significant terms (Zupic & Čater, 2014). Subsequently, all of the resulting visualisations were verified, interpreted and discussed by both researchers.

Ethical Consideration

This study is a bibliometric analysis that does not involve human participants; therefore, ethical approval was not required.

Results

Volume and Type of Publication

Based on the article search conducted using the Publish or Perish application, a total of 90 research articles related to prehospital airway suction published over the past 20 years were identified. Of these, 47 articles were sourced from Scopus and 43 from PubMed. All collected articles were screened for duplication using Mendeley Desktop. Among the 90 articles, 71 (78.89%) addressed themes related to prehospital airway suction. These comprised 85.92% original research articles (n=61), 7.04% review articles (n=5), 2.82% case reports (n=2), 1.41% evaluation study (n=1), 1.41% abstract (n=1), and 1.41% book chapter (n=1).

Following classification by type, the temporal distribution of these publications was examined to identify patterns in research growth.

Growth Research Analysis

Over the past two decades (2005–2025), the number of research publications on prehospital airway suction has fluctuated. During this period, there were three years—2005, 2008, and 2013—in which no publications on the topic were found. The highest number of publications occurred in 2022, with a total of 12 articles. Nevertheless, as shown in Figure 2, the publication trend on prehospital airway

Table 1. Top 10 Most Cited Publications about prehospital airway suction over the last two decades (from 2005 to 2025)

Rangking	Author (year)	Source	Cited by
1st	Prekker et al. (2014)	Critical Care Medicine	79
2nd	Schalk et al. (2010)	Resuscitation	70
3rd	Bernhard et al. (2015)	Anasthesiologie und Intensivmedizin	29
4th	Hossfeld et al. (2021)	European Journal of Anaesthesiology	28
5th	Barker et al. (2010)	Wilderness and Environmental Medicine	25
6th	Schalk et al. (2011)	Prehospital Emergency Care	22
7th	Black, (2007)	Emergency Medicine Journal	22
8th	Bernhard et al. (2015)	Notfall und Rettungsmedizin	20
9th	Schalk et al., (2012)	Anaesthesist	20
10th	Dengler et al. (2011)	Anaesthesist	19

Table 2. Publications related to portable suction (2005–2025) retrieved from Scopus and PubMed databases

Author (year)	Source
Schalk et al. (2011)	Prehospital Emergency Care
Dengler et al. (2011)	Anaesthesist
Suzuki et al. (2019)	PloS one
Peri et al. (2025)	Annals of Biomedical Engineering

Table 3. Publications related to the SALAD technique (2005–2025) retrieved from Scopus and PubMed databases

Author (year)	Source
Bernhard et al. (2015)	Anasthesiologie und Intensivmedizin
Otten et al. (2017)	Journal of special operations medicine : a peer reviewed journal for SOF medical professionals
Jensen et al. (2019)	Air medical journal
Jain et al. (2020)	Prehospital and Disaster Medicine
Guillote et al. (2024)	Prehospital emergency care

suction has demonstrated a steady increase from 2023 to 2025.

Most Cited Publications

As shown in Table 1, the ten most frequently cited publications can be identified. Ranked first is an article authored by Prekker et al., (2014), published in Critical Care Medicine, which has been cited 79 times. Furthermore, Table 2 presents articles related to prehospital airway suction over the past 20 years. According to this table, four articles specifically discuss portable suction devices, namely those by Schalk et al., 2011, Dengler et al., (2011), Suzuki et al., (2019), and Peri et al., (2025).

Co-occurrence Terms and Topic Analysis

Based on the network visualisation, the bibliometric structure revealed five main clusters, each represented by a different colour, indicating the relationships among terms within the literature (van Eck & Waltman, 2010). Each cluster represents a distinct research focus (Donthu et al., 2021). The red cluster consists of 25 terms focusing on airway devices and preparation. Advanced airway management is critically required in the prehospital setting to improve patient outcomes (Carney et al., 2021; Nah et al., 2024). The green cluster comprises 24 terms related to healthcare personnel and the management of prehospital airways. The

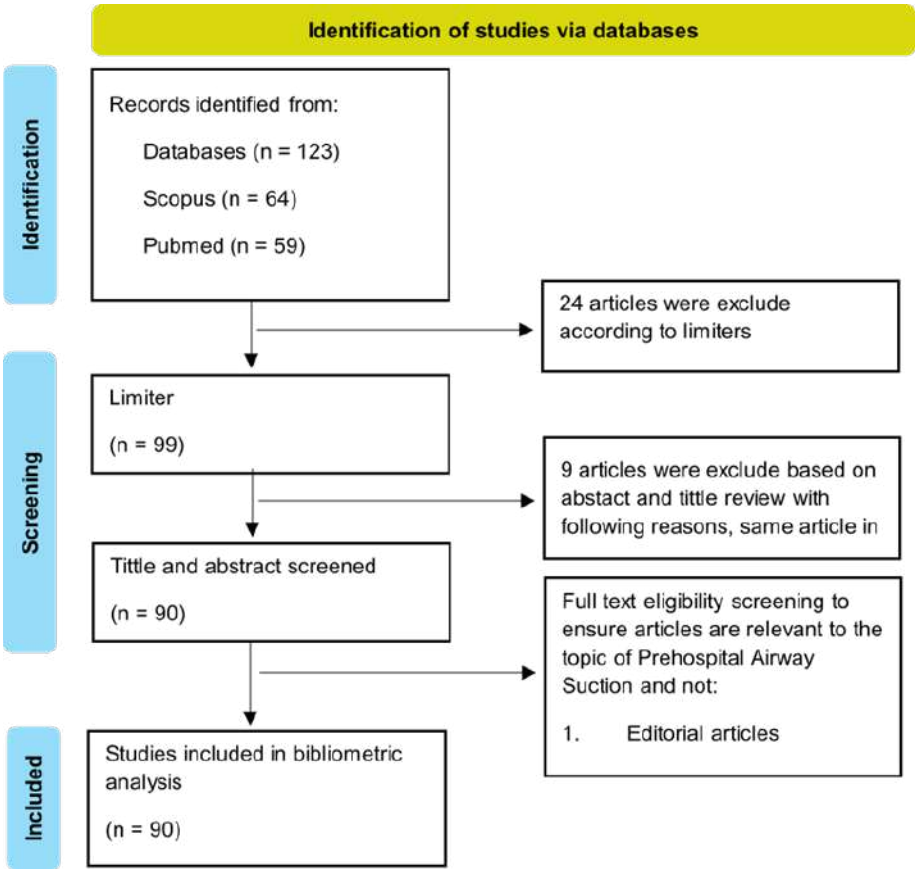

Figure 1. Prisma 2020 Flow Diagram Adapted for Bibliometric Analysis

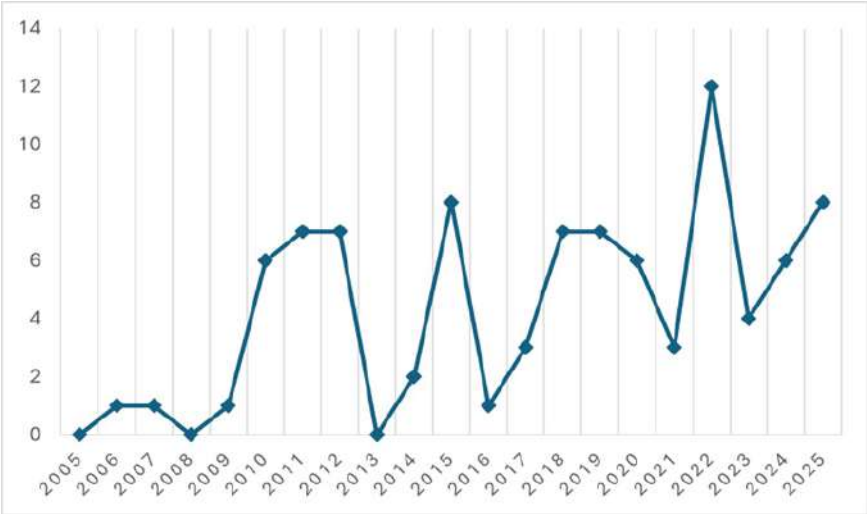

Figure 2. Graph illustrating the growth of research outputs on prehospital airway suction from 2005

blue cluster includes 23 terms concerning the use of suction and evidence-based clinical efficacy. Current systematic reviews on the use of portable suction devices have identified a lack of standardisation and high-quality evidence regarding their safety, effectiveness, and potential adverse effects in prehospital settings, particularly in the management of combat casualties (Jain et al., 2020). The yellow cluster is composed of 23 terms that centre on intubation procedures and field-related challenges. The final cluster, represented in purple, consists of 21 terms highlighting a focus on clinical outcomes

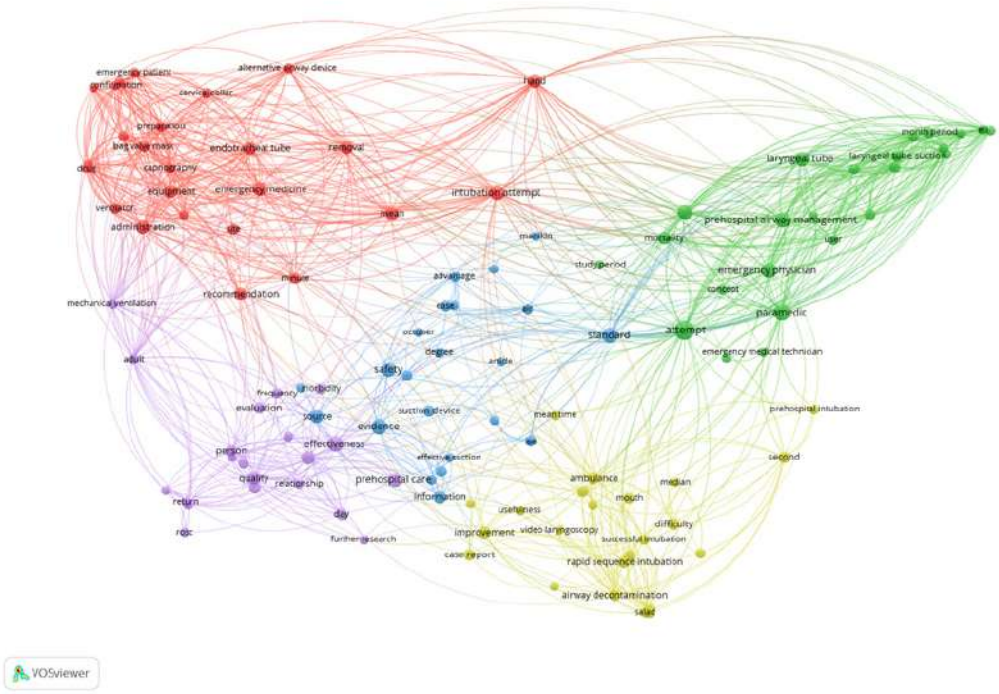

Figure 3. Co-occurrence network visualisation of title and abstract terms in prehospital airway suction research between 2005 and 2025

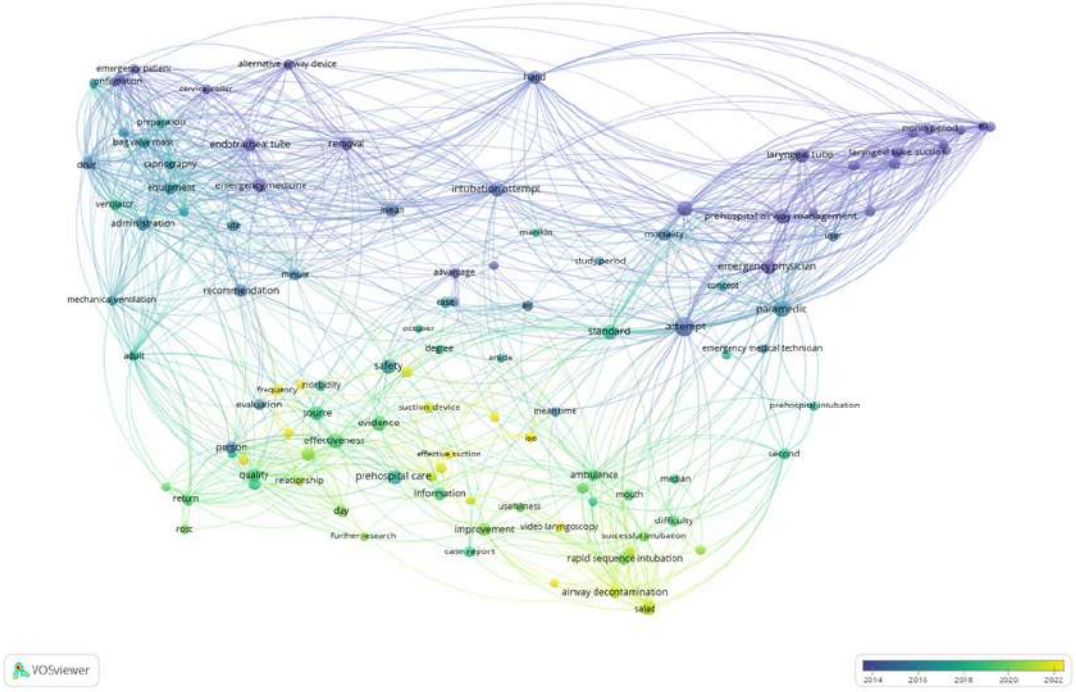

Figure 4. Overlay visualisation of co-occurring terms in the title and abstract of prehospital airway suction publications (2005–2025)

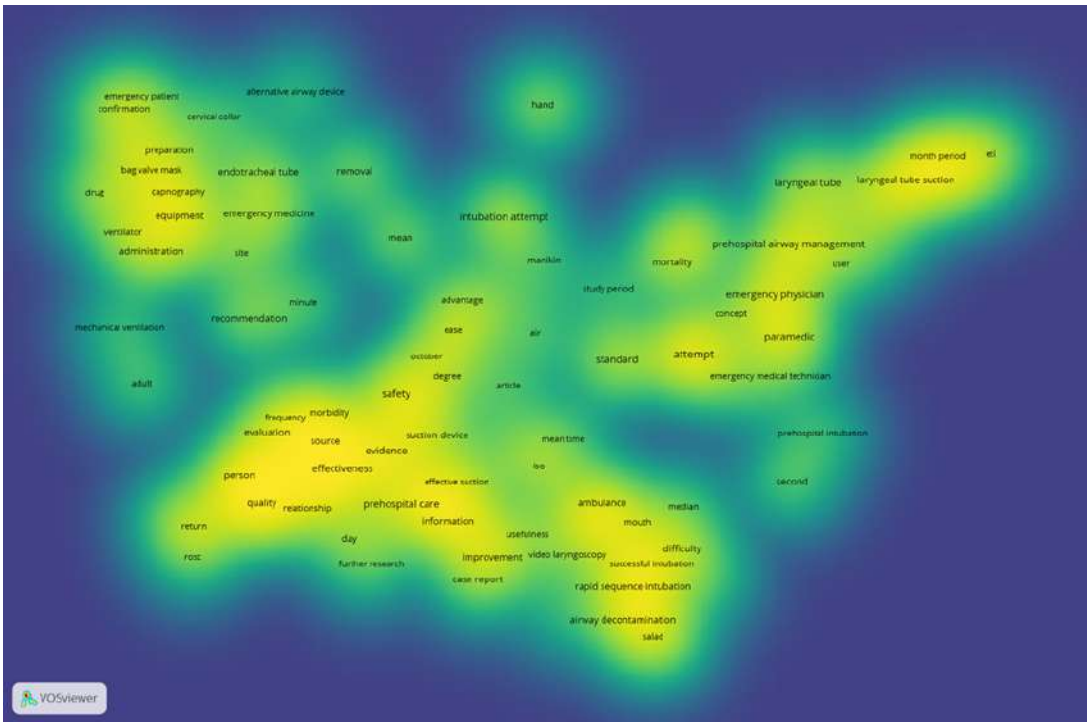

Figure 5. Density visualisation of co-occurring terms in the title and abstract of prehospital airway suction publications (2005–2025)

and the evaluation of prehospital care.

The overlay visualisation (Figure 4) indicates that terms such as bag-valve mask, preparation, and emergency medicine were dominant in earlier years, particularly between 2014 and 2016, as represented by bluish-purple colouring. In contrast, more recent years have seen the emergence of terms such as airway decontamination, SALAD, and suction device, which are highlighted in bright yellow. This trend reflects a shift in focus from basic airway adjuncts to more advanced tools such as portable suction devices (Peri et al., 2025) and innovative suction techniques like SALAD (Guillote et al., 2024), as well as increasingly complex procedures in airway management.

To explore this trend further, the researchers conducted an in-depth review of the 90 articles retrieved from Scopus and PubMed using the Publish or Perish application. The aim was to identify articles discussing portable suction devices and advanced suction techniques. As a result, five articles addressing portable suction were identified (Table 2), along with six articles focusing on the SALAD technique (Table 3).

The density visualisation (Figure 5) highlights the most frequent and densely occurring terms, such as effectiveness, safety, prehospital care, suction device, attempt, emergency physician, and paramedic. These terms represent the most extensively discussed areas in global research on prehospital airway suction. Their bright yellow colouring indicates both high frequency and strong connectivity within the bibliometric network (Donthu et al., 2021; van Eck & Waltman, 2010).

Discussion

The analysis using VOSviewer revealed that all articles discussing prehospital airway suction formed five main clusters. The red cluster consists of 25 terms focusing on Airway Devices & Preparation, including terms such as bag-valve mask, endotracheal tube, emergency medicine, preparation, capnography, confirmation, cervical collar, and alternative airway device. This cluster conceptually represents a paradigm shift in pre-hospital airway management, from a device-based approach to a holistic approach that emphasises clinical readiness and physiological confirmation prior to intervention. Current trends indicate that successful airway management is determined not only by technical skills, but also by systematic preparation, pre-intubation assessment, and real-time capnography monitoring, which have been shown to improve first-pass success and the chances of return of spontaneous circulation (ROSC) (Berkenbush et al., 2023; Jarvis et al., 2024; Liaqat et al., 2025; Panchal et al., 2020).

The green cluster focuses on healthcare professionals and the management of prehospital airways. Key terms within this cluster include paramedic, emergency physician, prehospital airway management, laryngeal tube, laryngeal tube suction, attempt, and emergency medical technician. This cluster highlights studies that emphasise the

role of medical professionals, the effectiveness of airway manoeuvres, and the implementation of airway procedures. A study on out-of-hospital cardiac arrest patients demonstrated that the success rate of advanced airway placement by paramedics increased significantly when operators had high case exposure and participated in regular simulation-based training (Tuttle & Hubble, 2018). Moreover, paramedics with experience in using laryngeal tubes and laryngeal tube suction achieved higher first-pass success rates (Dyson et al., 2017).

The blue cluster is related to the use of suction and evidence-based clinical efficacy. Key terms appearing in this cluster include suction device, effective suction, safety, effectiveness, evidence, information, improvement, ISO, and mean time. This cluster reflects scientific interest in the safety and efficiency of portable suction devices in a pre-hospital setting, while highlighting the technical challenges that remain in the field. Recent research shows that many portable suction devices still have limited suction power, are heavy, and have slow emptying times, thereby reducing their effectiveness in emergency situations that require a rapid response (Jain et al., 2020; Peri et al., 2025). In line with this, several studies emphasise the importance of standardising device performance based on ISO regulations and evidence-based evaluation, so that suction devices can guarantee patient safety and consistency of clinical results in various pre-hospital settings (Dudziński et al., 2023). This trend indicates a shift in research focus from simply testing device functionality towards developing suction technology that is ergonomic, energy efficient, and integrated with clinical safety protocols.

The yellow cluster focuses on intubation procedures and field-related challenges. Key terms in this cluster include rapid sequence intubation, video laryngoscopy, airway decontamination, difficulty, successful intubation, SALAD technique, ambulance, median, and mouth. Several previous studies have shown that training in the Suction-Assisted Laryngoscopy and Airway Decontamination (SALAD) technique significantly reduces intubation failure rates, decreases aspiration volume, and achieves first-pass success rates comparable to conventional methods (Berkenbush et al., 2023; Guillote et al., 2024; Jensen et al., 2020). Scientifically, this trend indicates a shift in research focus towards improving operator safety and mitigating aspiration risks through simulation-based techniques and visualisation technologies such as video laryngoscopy, which is now the standard of modern training in ambulance and emergency services environments. Thus, this cluster emphasises the importance of integrating technical skills, visual aids, and airway decontamination strategies to optimise the success of intubation in challenging field conditions.

The purple cluster highlights a focus on clinical outcomes and the evaluation of prehospital care. Key terms in this cluster include prehospital care, morbidity, frequency, evaluation, return of spontaneous circulation (ROSC), quality, further research, and relationship. This cluster conceptually represents a shift in research orientation from technical procedures towards assessing the effectiveness and quality of services, reflecting global efforts to assess the extent to which pre-hospital interventions contribute to patient safety and outcomes. Evaluations of prehospital care systems have identified variations in outcome quality, highlighting the need for ongoing performance monitoring, benchmarking, and targeted training to reduce morbidity and mortality (Amaleh et al., 2024). In addition, recent research emphasises the importance of integrating clinical outcome indicators such as ROSC and resuscitation quality as key parameters in evaluating the quality of emergency services (Takayama et al., 2025; Wang et al., 2022). This cluster underscores an emphasis on patient outcomes, the effectiveness of interventions, and research areas that warrant further exploration.

Data analysis reveals that the primary focus of global literature centres around three key aspects: the efficacy of suction procedures, technical challenges in the field, and the role of healthcare providers. Terms such as effectiveness and safety indicate a strong emphasis on evidence-based procedural validation (Berkenbush et al., 2023). Meanwhile, the emergence of terms like “airway decontamination” and “SALAD” reflects the adoption of novel techniques to address complex airway challenges (Guillote et al., 2024; Jensen et al., 2019). Several studies have demonstrated that video laryngoscopy and SALAD (Suction-Assisted Laryngoscopy and Airway Decontamination) enhance airway visibility and improve first-pass intubation success rates (Berkenbush et al., 2023; Eberlein et al., 2019; Maissan et al., 2022). Additionally, prior research has emphasised that the effectiveness of suction is highly dependent on both the equipment used and the skill level of the operator (Dudziński et al., 2023; Peri et al., 2022).

The correlation between terms indicates a strong association between prehospital care and terms such as evidence, morbidity, and evaluation. Prehospital airway suction is a critical intervention in cases of trauma, cardiac arrest, or respiratory arrest due to airway obstruction (Jain et al., 2020; Lorenzen et al., 2024). The success of suction procedures has a direct impact on Return of Spontaneous Circulation (ROSC) and contributes to reducing both morbidity and mortality (Carney et al., 2021; Takayama et al., 2025; Wang et al., 2022). This highlights the importance of outcome measurement in the context of airway interventions in out-of-hospital settings (Nishimura et al., 2022).

The terms paramedic, emergency physician, and emergency medical technician underscore the critical importance of operator skill in the success of suction procedures. Previous studies have shown that paramedic competence in airway suctioning is directly correlated with patient outcomes (Carney et

al., 2021; Panchal et al., 2020). Therefore, regular simulation-based training and protocol updates are strongly recommended. Earlier research has highlighted the significance of simulation-based training in enhancing airway suction skills (Jensen et al., 2019).

The overlay visualisation indicates that terms such as SALAD, airway decontamination, and improvement have emerged more recently (2020–2022), signalling current research directions. Additionally, the appearance of the term further research highlights existing gaps in the literature, particularly regarding new devices (Johnson et al., 2022), extreme emergency environments (Jain et al., 2020), and longitudinal evaluation of suction procedures (Jarvis et al., 2024). This presents an opportunity for larger clinical studies with prospective designs.

Limitation of the study

This is the first bibliometric study to specifically explore the topic of prehospital airway suction. As such, the findings of this research may serve as a valuable reference for future researchers in selecting themes for further investigation within the domain of prehospital airway suction. Nevertheless, this study has several limitations that should be acknowledged. First, it relied solely on two publication databases (Scopus and PubMed). Second, the analysis was limited to the keyword prehospital airway suction, thereby excluding relevant studies that may have used alternative terms such as prehospital airway management. It is hoped that these limitations can be addressed in future bibliometric research.

Implication of the study

Implication for nursing research

This bibliometric analysis shows that research discussing prehospital airway suction is still limited in number. More specifically, there is a lack of research discussing the effectiveness of portable suction devices, suction techniques such as SALAD, and the effect of suction on patient outcomes in emergency conditions. This gap indicates a need for further research on these topics. Furthermore, this bibliometric analysis also shows a shift in trends towards innovation in advanced devices and simulations. These results open up great opportunities for nursing researchers to collaborate with experts in the field of electromedicine to design advanced portable suction technology that is effective in improving patient outcomes and, at the same time, is easy to move and robust (can be used in all types of terrain outside the hospital area, especially on extreme emergency scenarios).

Implication for nursing education

The results of this bibliometric analysis confirm that the skills of personnel (including nurses) greatly influence the success of airway suction outside of hospitals, especially when dealing with airway contamination (such as blood, vomit, or thick secretions). Therefore, nursing education institutions must strengthen their curriculum on airway management. This can be achieved through simulation-based training with scenarios involving severe contamination. The improvement of these skills must go beyond technical aspects to include clinical decision making, risk assessment, and critical situation management. Furthermore, continuing education for emergency nurses and ambulance nurses must be conducted regularly to maintain and improve their skills.

Implication for nursing practice

The results of this study emphasise the need for standardization of suction procedures. This is to ensure that suction techniques are safe, effective, and produce consistent results, including in situations outside of hospitals. Emergency nurses must perform suction procedures in accordance with evidence-based practices, which include decontamination techniques, safe suction duration, selection of appropriate suction devices, and management of challenging emergency environments. Furthermore, nurses must continuously improve their suction skills in accordance with standardized procedures. With improved nursing skills, suction equipment readiness, and compliance with procedures, nursing practice will directly contribute to successful airway management and improved patient safety.

Conclusion

This bibliometric study indicates that prehospital airway suction is an evolving topic, with research focusing on effectiveness, technical challenges, and the role of medical personnel. The emergence of terms such as further research, improvement, and evaluation suggests that although substantial evidence on prehospital airway suction is available, many variables remain unstandardized. There is a clear need for procedural standardization (Peri et al., 2025), the development of portable and efficient devices (Jain et al., 2020), advancement of effective suction techniques (Patterson et al., 2021), and the enhancement of simulation-based clinical training for paramedics and medical personnel (Halabi et al., 2022; Zucca et al., 2024). Future research should target specific populations, extreme emergency scenarios, and the integration of emerging technologies due to the lack of research on these themes. Even though these themes are real conditions that occur in prehospital emergency services.

Declaration of Interest

The authors affirm that there are no conflicts of interest associated with this study.

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Data Availability

The dataset generated during this study is available from the corresponding author on reasonable request.

References

Amaleh, K. M. H., Heydari, S., Nazari, P., & Bakhshi, F. (2024). Evaluating the effectiveness of the pre hospital trauma life support (PHTLS) program for the management of trauma patients in the pre-hospital emergency based on Kirkpatrick's evaluation model. *International Journal of Emergency Medicine, 17*(1), 13. https://doi.org/10.1186/s12245-024-00589-2

Barker, S., Charlton, N. P., & Holstege, C. P. (2010). Accuracy of internet recommendations for prehospital care of venomous snake bites. *Wilderness and Environmental Medicine, 21*(4), 298–302. https://doi.org/10.1016/j.wem.2010.08.016

Berkenbush, M., Feldman, D., Ritter, A., Dwyer, R., Petersen, D., & Allegra, J. R. (2023). High performance prehospital airway management: Raising the bar with education, rapid sequence intubation, suction assisted laryngoscopy airway decontamination, video laryngoscopy, and skills proficiency. *JEM Reports, 2*(1), 100012. https://doi.org/10.1016/j.jemrpt.2023.100012

Bernhard, M., Bein, B., Böttiger, B. W., Bohn, A., Fischer, M., Gräsner, J. T., Hinkelbein, J., Kill, C., Lott, C., Popp, E., Roessler, M., Schaumberg, A., Wenzel, V., & Hossfeld, B. (2015). Practice management guideline on prehospital emergency anaesthesia: Working group "Prehospital emergency anaesthesia" of the scientific working group on emergency medicine of the German Society of Anaesthesiology and Intensive Care Medicine. *Notfall Und Rettungsmedizin, 18*(5), 395–412. https://doi.org/10.1007/s10049-015-0041-9

Bernhard, M., Hossfeld, B., Bein, B., Böttiger, B. W., Bohn, A., Fischer, M., Gräsner, J.-T., Hinkelbein, J., Kill, C., Lott, C., Popp, E., Roessler, M., Schaumberg, A., & Wenzel, V. (2015). Recommendation for action: Prehospital emergency anesthesia in adults. *Anasthesiologie und Intensivmedizin, 56,* 317–335. https://www.scopus.com/pages/publications/84937849706?origin=resultslist#

Black, J. J. M. (2007). Emergency use of the Airtraq laryngoscope in traumatic asphyxia: Case report. *Emergency Medicine Journal, 24*(7), 509–510. https://doi.org/10.1136/emj.2006.040469

Brainard, C., & Gerecht, R. (2015, August 14). Overview of Prehospital Airway Suctioning. *Journal of Emergency Medical Services (JEMS).* https://www.jems.com/patient-care/airway-respiratory/overview-of-prehospital-airway-suctioning/

Carney, N., Totten, A. M., Cheney, T., Jungbauer, R., Neth, M. R., Weeks, C., Davis-O'Reilly, C., Fu, R., Yu, Y., Chou, R., & Daya, M. (2021). Prehospital airway management: A systematic review. *Prehospital Emergency Care, 26*(5), 716–727. https://doi.org/10.1080/10903127.2021.1940400

Dengler, V., Wilde, P., Byhahn, C., Mack, M. G., & Schalk, R. (2011). Prehospital airway management of laryngeal tubes. Should the laryngeal tube S with gastric drain tube be preferred in emergency medicine? *Der Anaesthesist, 60*(2), 135–138. https://doi.org/10.1007/s00101-010-1774-y

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133,* 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dudziński, Ł., Kubiak, T., Feltynowski, M., Panczyk, M., & Leszczyński, P. (2023). Performance of portable emergency suction devices in pre-hospital conditions: A pilot study in the fire brigade. *Folia Medica Cracoviensia, 63*(1), 79–90. https://doi.org/10.24425/fmc.2023.145431

Dunne, C. L., Peden, A. E., Queiroga, A. C., Gomez Gonzalez, C., Valesco, B., & Szpilman, D. (2020). A systematic review on the effectiveness of anti-choking suction devices and identification of research gaps. *Resuscitation, 153,* 219–226. https://doi.org/10.1016/j.resuscitation.2020.02.021

Dyson, K., Bray, J. E., Smith, K., Bernard, S., Straney, L., Nair, R., & Finn, J. (2017). Paramedic intubation experience is associated with successful tube placement but not cardiac arrest survival. *Annals of Emergency Medicine, 70*(3), 382-390.e1. https://doi.org/10.1016/j.annemergmed.2017.02.002

Eberlein, C. M., Luther, I. S., Carpenter, T. A., & Ramirez, L. D. (2019). First-pass success intubations using video laryngoscopy versus direct laryngoscopy: A retrospective prehospital ambulance service study. *Air Medical Journal, 38*(5), 356–358. https://doi.org/10.1016/j.amj.2019.06.004

Gage, C. B., Powell, J. R., Bosson, N., Crowe, R., Guild, K., Yeung, M., Maclean, D., Browne, L. R., Jarvis, J. L., Sholl, J. M., Lang, E. S., & Panchal, A. R. (2023). Evidence-based guidelines for prehospital airway management: methods and resources document. *Prehospital*

Emergency Care, 28(4), 561–567. https://doi.org/10.1080/10903127.2023.2281377

Gage, C. B., Powell, J. R., Nassal, M., Wang, H., & Panchal, A. R. (2023). Secular trends in airway management of out-of-hospital cardiac arrest in the National Emergency Medical Services Information System (NEMSIS) dataset. *Resuscitation, 193,* 110024. https://doi.org/10.1016/j.resuscitation.2023.110024

Guillote, C. P., Root, C. W., Braude, D. A., Decker, C. A., Romero, A. P., Perez, N. E., & DuCanto, J. C. (2024). Prehospital SALAD airway technique in an adolescent with penetrating trauma case report. *Prehospital Emergency Care, 28*(7), 965–969. https://doi.org/10.1080/10903127.2024.2360688

Halabi, O., Salahuddin, T., Karkar, A. G., & Alinier, G. (2022). Virtual reality for ambulance simulation environment. *Multimedia Tools and Applications, 81*(22), 32119–32137. https://doi.org/10.1007/s11042-022-12980-3

Hossfeld, B., Thierbach, S., Allgoewer, A., Gaessler, H., & Helm, M. (2021). First pass success of tracheal intubation using the C-MAC PM videolaryngoscope as first-line device in prehospital cardiac arrest compared with other emergencies: An observational study. *European Journal of Anaesthesiology, 38*(8), 806–812. https://doi.org/10.1097/EJA.0000000000001286

Jacobs, P. E., & Grabinsky, A. (2014). Advances in prehospital airway management. *International Journal of Critical Illness and Injury Science, 4*(1). https://doi.org/10.4103/2229-5151.128014

Jain, P., Akhter, F., Schoppe, A., Hood, R. L., & De Lorenzo, R. A. (2020). Airway clearance using suction devices in prehospital combat casualty care: A systematic review. *Prehospital and Disaster Medicine, 35*(6), 676–682. https://doi.org/10.1017/S1049023X20001065

Jarvis, J. L., Panchal, A. R., Lyng, J. W., Bosson, N., Donofrio-Odmann, J. J., Braude, D. A., Browne, L. R., Arinder, M., Bolleter, S., Gross, T., Levy, M., Lindbeck, G., Maloney, L. M., Mattera, C. J., Wang, C. T., Crowe, R. P., Gage, C. B., Lang, E. S., & Sholl, J. M. (2024). Evidence-based guideline for prehospital airway management. *Prehospital Emergency Care, 28*(4), 545–557. https://doi.org/10.1080/10903127.2023.2281363

Jensen, M., Barmaan, B., Orndahl, C. M., & Louka, A. (2020). Impact of suction-assisted laryngoscopy and airway decontamination technique on intubation quality metrics in a helicopter emergency medical service: An educational intervention. *Air Medical Journal, 39*(2), 107–110. https://doi.org/10.1016/j.amj.2019.10.005

Jensen, M., Louka, A., & Barmaan, B. (2019). Effect of Suction Assisted Laryngoscopy Airway Decontamination (SALAD) training on intubation quality metrics. *Air Medical Journal, 38*(5), 325. https://doi.org/10.1016/j.amj.2019.07.002

Johnson, S. A., Lauby, R. S., Hood, R. L., De Lorenzo, R. A., & Schauer, S. G. (2022). A market review of available airway suction technology. *Prehospital and Disaster Medicine, 37*(3), 390–396. https://doi.org/10.1017/S1049023X22000437

Kibblewhite, C., Todd, V. F., Howie, G., Sanders, J., Ellis, C., Dittmer, B., Garcia, E., Swain, A., Smith, T., & Dicker, B. (2023). Out-of-Hospital emergency airway management practices: A nationwide observational study from Aotearoa New Zealand. *Resuscitation Plus, 15*, 100432. https://doi.org/10.1016/j.resplu.2023.100432

Kumar, M., Kumari, S., Guntipally, S. S., Chhabra, A., Kumar, A., & Kumar, P. (2024). A step-by-step guide of bibliometric study for healthcare and allied research. *Journal of Pharmacy and Bioallied Sciences, 16*(Suppl 4). https://doi.org/10.4103/jpbs.jpbs_1347_24

Liaqat, T., Amjad, M. A., & Cherian, S. (2025). Difficult airway management in the intensive care unit: A narrative review of algorithms and strategies. *Journal of Clinical Medicine, 14*(14), 4930. https://doi.org/10.3390/jcm14144930

Lorenzen, U., Marung, H., Eimer, C., Köser, A., Seewald, S., Rudolph, M., & Reifferscheid, F. (2024). Quality and safety in prehospital airway management – retrospective analysis of 18,000 cases from an air rescue database in Germany. *BMC Emergency Medicine, 24*(1), 157. https://doi.org/10.1186/s12873-024-01075-x

Maissan, I., van Lieshout, E., de Jong, T., van Vledder, M., Houmes, R. J., Hartog, D. den, & Stolker, R. J. (2022). The impact of video laryngoscopy on the first-pass success rate of prehospital endotracheal intubation in The Netherlands: A retrospective observational study. *European Journal of Trauma and Emergency Surgery, 48*(5), 4205–4213. https://doi.org/10.1007/s00068-022-01962-7

Nah, S., Lee, Y., Choi, S., Lee, J., Hwang, S., Lim, S., Lee, I., Cho, Y., & Chung, H. (2024). The current trend of emergency airway management: A clinical review. *Clinical and Experimental Emergency Medicine, 11*. https://doi.org/10.15441/ceem.23.173

Nishimura, T., Suga, M., Nakao, A., Ishihara, S., & Naito, H. (2022). Prehospital advanced airway management of emergency medical service-witnessed traumatic out-of-hospital cardiac arrest patients: Analysis of nationwide trauma registry . *Acute Medicine & Surgery, 9*(1). https://doi.org/10.1002/ams2.786

Otten, E. J., Montgomery, H. R., & Butler, F. K. (2017). Extraglottic airways in tactical combat casualty care: TCCC guidelines change 17-01 28 August 2017. *Journal of Special Operations Medicine : A Peer Reviewed Journal for SOF*

*Medical Professionals, 17(*4), 19–28. https://doi.org/10.55460/nq9d-at5x

Öztürk, O., Kocaman, R., & Kanbach, D. K. (2024). How to design bibliometric research: An overview and a framework proposal. *Review of Managerial Science, 18*(11), 3333–3361. https://doi.org/10.1007/s11846-024-00738-0

Panchal, A. R., Finnegan, G., Way, D. P., & Terndrup, T. (2020). Assessment of paramedic performance on difficult airway simulation. *Prehospital Emergency Care, 24*(3), 411–420. https://doi.org/10.3109/10903127.2015.1102993

Patterson, E., Tang, H. T., Ji, C., Perkins, G. D., & Couper, K. (2021). The efficacy and usability of suction-based airway clearance devices for foreign body airway obstruction: A manikin randomised crossover trial. *Resuscitation Plus, 5,* 100067. https://doi.org/https://doi.org/10.1016/j.resplu.2020.100067

Peri, S. R., Akhter, F., De Lorenzo, R. A., & Hood, R. L. (2022). Portable medical suction and aspirator devices: Are the design and performance standards relevant? *Sensors, 22*(7), 2515. https://doi.org/10.3390/s22072515

Peri, S. R., Akhter, F., De Lorenzo, R. A., & Hood, R. L. (2025). A better standard to assess the performance of portable suction devices: Time-averaged air flow rate. *Annals of Biomedical Engineering.* https://doi.org/10.1007/s10439-025-03764-5

Prekker, M. E., Kwok, H., Shin, J., Carlbom, D., Grabinsky, A., & Rea, T. D. (2014). The process of prehospital airway management: Challenges and solutions during paramedic endotracheal intubation. *Critical Care Medicine, 42*(6), 1372–1378. https://doi.org/10.1097/CCM.0000000000000213

Schalk, R., Auhuber, T., Haller, O., Latasch, L., Wetzel, S., Weber, C. F., Ruesseler, M., & Byhahn, C. (2012). Implementierung des larynxtubus im präklinischen atemwegsmanagement: Ausbildung von 1069 notärzten und rettungsassistenten [Implementation of the laryngeal tube for prehospital airway management: Training of 1,069 emergency physicians and paramedics]. *Der Anaesthesist, 61*(1), 35–40. https://doi.org/10.1007/s00101-011-1966-0

Schalk, R., Byhahn, C., Fausel, F., Egner, A., Oberndörfer, D., Walcher, F., & Latasch, L. (2010). Out-of-hospital airway management by paramedics and emergency physicians using laryngeal tubes. *Resuscitation, 81*(3), 323–326. https://doi.org/10.1016/j.resuscitation.2009.11.007

Schalk, R., Meininger, D., Ruesseler, M., Oberndörfer, D., Walcher, F., Zacharowski, K., Latasch, L., & Byhahn, C. (2011). Emergency airway management in trauma patients using laryngeal tube suction. *Prehospital Emergency Care, 15*(3), 347–350. https://doi.org/10.3109/10903127.2011.561405

Sontakke, N. G., Sontakke, M. G., & Rai, N. K. (2023). Artificial airway suctioning: A systematic review. *Cureus, 15*(7), e42579. https://doi.org/10.7759/cureus.42579

Suzuki, K., Kusunoki, S., Sadamori, T., Tanabe, Y., Itai, J., & Shime, N. (2019). Comparison of video and conventional laryngoscopes for simulated difficult emergency tracheal intubations in the presence of liquids in the airway. *PLOS ONE, 14*(7), e0220006. https://doi.org/10.1371/journal.pone.0220006

Takayama, W., Sugimoto, M., Morishita, K., Otomo, Y., Kitamura, N., Tagami, T., & Group, O. B. of the S.-K. 2017 S. (2025). Comparison of outcomes between successful and failed prehospital advanced airway management by paramedic staff in patients with out-of-hospital cardiac arrest. *European Journal of Emergency Medicine.* https://doi.org/10.1097/MEJ.0000000000001231

Tuttle, J., & Hubble, M. (2018). Paramedic Out-of-hospital cardiac arrest case volume is a predictor of return of spontaneous circulation. *Western Journal of Emergency Medicine, 19,* 654–659. https://doi.org/10.5811/westjem.2018.3.37051

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84(*2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Wang, Y., Zhang, Q., Qu, G. B., Fang, F., Dai, X. K., Yu, L. X., & Zhang, H. (2022). Effects of prehospital management in out-of-hospital cardiac arrest: Advanced airway and adrenaline administration. *BMC Health Services Research, 22*(1), 546. https://doi.org/10.1186/s12913-022-07890-x

Warnock, L., & Gates, A. (2023). Airway clearance techniques compared to no airway clearance techniques for cystic fibrosis. *Cochrane Database of Systematic Reviews, 4.* https://doi.org/10.1002/14651858.CD001401.pub4

Zucca, A., Bryant, J., Purse, J., Szwec, S., Sanson-Fisher, R., Leigh, L., Richer, M., & Morrison, A. (2024). Evaluation of the effectiveness of advanced technology clinical simulation manikins in improving the capability of australian paramedics to deliver high-quality cardiopulmonary resuscitation: Pre- and postintervention study. *JMIR Cardio, 8*(1), e49895. https://doi.org/10.2196/49895

Zupic, I., & Čater, T. (2014). Bibliometric methods in management and organization. *Organizational Research Methods, 18*(3), 429–472. https://doi.org/10.1177/1094428114562629