BIBLIOMETRIC ANALYSES

Do not invade, just support

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ABSTRACT

BACKGROUND: Since the first attempts for ventilation, there have been significant changes in terms of the size of devices, ventilation techniques, and technology. In time, invasive methods and huge devices were replaced by non-invasive methods and small and portable devices. Increased use of non-invasive methods was followed by enrichment of literature on the topic. This study aimed to determine the evolution of non-invasive ventilation (NIV) literature and predict future trends.

MATERIALS AND METHODS: We used the Web of Science database for search. To include all papers, we searched multiple keywords, including "non-invasive ventilation, non-invasive positive pressure, continuous positive airway pressure, CPAP, NIV." All articles that meet the criteria published in the respiratory system, critical care medicine, anesthesiology, and emergency medicine fields during 1975–2020 were determined.

RESULTS: We made bibliometric analyses of 2847 original articles. However, the limited number of articles in the first years, published by year, exceeded a hundred with the new millennium and continues to increase. We predict that 233 and 334 papers will be published in 2021–2025, respectively. Most active countries were United States of America (576, 20.2 %), France (395, 13.8 %), Italy (293, 10.2 %). The most used keywords in NIV papers are non-invasive ventilation, continuous positive airway pressure and obstructive sleep apnea.

CONCLUSION: NIV technology and new devices are developing day by day. In addition, new areas of use have been defined by doctors. All these bring about new and different studies on NIV. We believe the present study that summarized the history and development of NIV literature will guide the authors who want to study this area (Tab. 4, Fig. 8, Ref. 19). Text in PDF www.elis.sk

KEYWORDS: bibliography, COPD, history, non-invasive ventilation, respiratory failure.

Introduction

The history of respiratory treatment began with the use of oxygen by Thomas Beddoes, the father of respiratory therapy, in the late 1700s, accelerated with the polio epidemic in the 1950s in Europe, and resulted in the discovery of highly skilled ventilators after the 1980s (1–3). During the polio epidemic, the first use of non-invasive ventilation started with negative pressure ventilators supporting ventilation by exposing the surface of the thorax to sub-atmospheric pressure. But it couldn’t be widely used because of giant machines, patients’ poor compliance, and its benefits weren’t supported by prospective studies.

Invasive ventilation has devastating effects on patients, including using an endotracheal tube, the need for sedation because the endotracheal tube is hard to tolerate, impaired cough, and conclusion with tracheostomy in case of prolonged intubation. The discovery of non-invasive positive-pressure ventilation met the remaining demand for non-invasive ventilation. This technique allowed to deliver needed tidal volume by a nasal, oronasal, or...
face mask and maintain the oral feeding and cough reflex. The improved machines allow enough volume and pressure, and they started to be used for several acute and chronic ventilatory disorders in the second half of the 1970s. The increasing number of intensive care units using non-invasive ventilators and expanding the use area bring new literature. Since then, numerous articles have been published examining non-invasive ventilation.

Bibliometrics is the analysis of scientific outputs and articles using statistical methods (4). Bibliometric analyses enable determining the most cited influential studies and journals, the most researched trending topics, the most active countries, institutions, journals, or authors in a subject or a research field (5). In addition, the general research trend of a subject in the world can be determined by introducing international collaborations.

This study aims to investigate non-invasive literature, define cornerstone papers, most productive authors, and countries, determine the top journals, and predict the future of non-invasive ventilation literature.

Materials and methods

We used the Web of Science (WoS) database for search. To include all papers about non-invasive ventilation, we searched the following keywords in WoS “non-invasive ventilation, non-invasive ventilation, non-invasive mechanical ventilation, non-invasive mechanical ventilation, continuous positive airway pressure, CPAP, bilevel positive airway pressure, BIPAP, HFNC, non-invasive positive pressure, NIPPV, and NIV” in the “title” section of articles.

<table>
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Fig. 2. Number of articles published on non-invasive ventilation by years and estimation of the number of articles that can be published in the future.

Fig. 3. World map for the distribution of articles by country on noninvasive ventilation. Footnote: In the indicator given at the bottom left of the figure, productivity increases from green to red.
All articles that meet the criteria published in the respiratory system, critical care medicine, anesthesiology, and emergency medicine fields during 1975–2020 were determined. (Date of access: 15.05.2021). Reproducibility codes for researchers to reach similar documents (search findings may vary depending on different access dates): (title: (“non invasive ventilation”) or title: (“non invasive mechanical ventilation”) or title: (“non invasive positive pressure”) or title: (“CPAP”) or title: (“bilevel positive airway pressure”) or title: (“BPAP”) or title: (“BiPAP”) (“non-invasive positive pressure”) or title: (“NIPPV”) or title: (“NIV”) Refined by: web of science categories: (respiratory system or critical care medicine or anesthesiology or emergency medicine) Timespan: 1975–2020. Indexes: SCI-Expanded, SSCI, A&HCI, CPCl-S, CPCl-SSH, BKCI-S, BKCI-SSH, ESCI).

VOS viewer (Version 1.6.15, Leiden University’s Centre for Science and Technology Studies) was used for bibliometric network visualizations. We used the https://app.datawrapper.de website for world map graphics. Statistical analyses were performed by using SPSS software version 22.0 (SPSS Inc., Chicago, IL, ABD). The normal distribution of data was tested with the Kol-
mogorov-Smirnov test. Spearman correlation coefficient was used to determine the effective indicators on the academic productivity on NIV, the number of articles produced by the world countries, and some economic development indicators of the world countries (Gross Domestic Product (GDP), Gross Domestic Product per capita (GDP per capita), Gross Domestic Product per capita), whose data were obtained from the world bank (6).

We used non-linear regression analyses to predict the number of articles in the future. The R2 value was used to evaluate model success in regression analysis. p < 0.05 was determined to infer statistical significance.

Results

There was no published paper between 1975–1980 in the WoS database. 13781 articles were published during 1980–2020. 7296 were in “Respiratory system, critical care medicine, emergency medicine, and anesthesiology. 2847 (39 %) was original article, 2810 (38.5 %) was meeting abstract, 797 (10.9 %) was letter. The remaining 842 papers consisted of editorial materials (400, 5.5 %), reviews (300, 4.1 %), proceedings papers (128, 1.8 %), and others (book chapter, correction note, early access, biographical item, book/book review, correction addition, news item, reprint, retracted publication). We made bibliometric analyses of 2847 original articles. 2669 (93.7 %) of the total articles were written in English. The H-index of these articles was 137, the average citation per article was 33.09, and the sum of times cited was 94202 (78333 without self-citations) (Fig. 1, Tab. 1).

The trend of publication and future prediction

We used non-linear regression analysis (exponential model) to estimate the number of articles in 2021 and beyond. To the prediction model, 233 (CI%: 205–261) and 334 (CI%: 275–392) articles will be published in 2021 and 2025, respectively (Fig. 2).

Active countries

The countries that published most articles (20 and more articles) were United States of America (USA) (576, 20.2 %), France (395, 13.8 %), Italy (293, 10.2 %), United Kingdom (UK) (249, 7.6 %), Spain (220, 7.7 %), Germany (206, 7.2 %), Japan (105, 3.6 %), Switzerland (102, 3.5 %), Turkey (84, 2.9 %), Brazil (80, 2.8 %), Belgium (65, 2.2 %), Netherlands (53, 1.8 %), Sweden (41, 1.4 %), India (40, 1.4 %), Greece (36, 1.2 %), Taiwan (36, 1.2 %), and Finland (31, 1 %) (Fig. 3). The international collaboration network visualization map between 44 countries producing at least 5 articles from 75 countries producing publications on NIV and cooperating is shown in Figure 4a and density map Figure 4b.

Correlation analysis

A statistically positive high and moderate correlation was found between the number of articles produced by countries on NIV and GDP (Gross Domestic Product), GDP per capita, GDP PPP (Gross Domestic Product at Purchasing Power Parity) and GDP per capita PPP. (r=0.712, p <0.001; r=0.618, p <0.001; r=0.701, p <0.001; r=0.614, p <0.001).
Active authors
Most productive authors who wrote more than 30 and more articles were Nava S (n=48), Pepin JL (n=46), Stradling JR (n=39), Brochard L (n=37), Conti G (n=32), Windisch W (n=31), and Navalesi P (n=30).

Active institutions
Most generative institutions published 20 and more articles were University of Toronto (n=55), Inserm (n=40), University of Sydney (n=39), University of Barcelona (n=38), Henri-Mondor University Hospital (n=33), University of Milano (n=33), University Cattolica Sacro Cuore (n=30), Massachusetts Gen Hospital (n=29), Royal Prince Alfred Hospital (n=27), University of Sao Paulo (n=27), University of Groningen (n=24), University of Laval (n=24), Churchill Hospital (n=23), University of California San Diego (n=23), Hospital of Clinic Barcelona (n=22), St Michaels Hospital (n=22), Harvard University (n=21), University of Paris 06 (n=21), Case Western Reserve University (n=20), University of Zurich (n=20).

Active journals
208 separate journals published 2847 articles about NIV. Journals that host ten and more articles, total citation numbers, and average citation per article are depicted in Table 2. The Citation network between these journals is presented in Figure 5.
Citation analysis
Among the articles published between 1980 and 2020, the first 17 articles with the highest number of citations (more than 300 citations) according to the total number of citations are presented in Table 3. In the last column of Table 3, the average number of citations per year is given.

Co-citation analysis
There were a total of 33325 studies cited in the references section of all 2847 articles analyzed. The first seven studies that received the most co-citations from these studies (more than 150 co-citations) were Brochard L (1995) (Number of co-citations, NC: 297), Sullivan CE (1981) (NC: 244), Johns MW (1991) (NC: 205), Young T (1993) (NC: 185), Plant PK (2000) (NC: 183), Kramer N (1995) (NC: 153), Bott J (1993) (NC: 150) (7–13).

Trend topics
The authors used 3432 different keywords in all 2847 articles published on NIV. Of these words, 126 different keywords were used in at least ten different articles (Tab. 4). The network visu-
Fig. 6. Network visualization map for cluster analysis based on keyword analysis on noninvasive ventilation. Colors show clustering. Keywords in the same cluster are of the same color.

Fig. 7. Network visualization map for trends on noninvasive ventilation. Indicator shows current publications from blue to red (blue–green–yellow–red).
Discussion

We found that the number of articles published about NIV is increasing day by day. As we showed in Figure 2, there were 0–50 articles (mean: 23) per year between 1980 and 1999, rising with a linear trend. The number of articles gained speed with the new millennium, and over a hundred papers were published every year after 2010. Non-linear regression analyses show that the number of articles will continue to increasing exponential trend (Fig. 2). We estimated that the number of publications would continue to increase and rise over three hundred by 2025. We think that it can be associated with two major topics. Firstly, we know that the number of intensive care units (ICU) is increasing over the years, correlating with the aging of the population and associated comorbidities. Kelly et al. stated that aging, increasing obesity, and disease candidates for treatment with new treatment modalities would require increasing ICUs (14). Considering factors such as smoking and air pollution, and microorganisms that threaten the respiratory tract (such as COVID), it is not difficult to predict that the need for intensive care and ventilators will grow. The second one is the expanding indications of NIV. Although NIV is primarily used for hypercapnic respiratory failure, especially for exacerbations of chronic obstructive pulmonary disease (COPD) and obstructive sleep apnea (OSA), it gains new usage areas such as neuromuscular diseases, cardiogenic pulmonary edema, hypoxemic respiratory failure (such as pneumonia), weaning, post-operative state, and support of bronchoscopy (15). Other benefits compared with invasive ventilation, such as reduced complication rate, reduction in the hospital stay, and mortality, also support the use of NIV (16). Taken together, consistent with our findings, we can expect that the use of NIV and, in correlation, the number of articles on NIV will increase.

Development degree seems like a good reflector of productivity. Sixteen of the twenty most productive countries are developed countries. The remaining four are developing countries (Turkey, China, India, and Brazil) with big economies. Correlation analysis showed that economic power is one of the most influential factors on scientific productivity in NIV (5, 17, 18). When we examined the co-authorship cooperation of countries on NIV, we found that cooperation based on geographical countries does not significantly affect article production. Collaborations were generally made in small clusters and were seen in the geographical neighborhood (Italy-Spain-Tunisia) and (France-Belgium-Switzerland) clusters (Fig. 4a). The density map created according to the collaboration score between countries showed that the most collaborative countries are France, the USA, Italy, UK, Canada, Spain, Switzerland, and Germany, respectively (Fig. 4b).

The most active authors and institutions were also consistent with countries. All active authors listed above are from Europe and North America. Similarly, only one institution, the University of Sao Paolo, was located outside Europe and North America.
The journals that published the most articles on NIV were determined as Chest, Respiratory Care, Sleep and Breathing, European Respiratory Journal, Intensive Care Medicine, American Journal of Respiratory and Critical Care Medicine, Pediatric Pulmonology, Thorax, Respiratory Medicine, and Critical Care Medicine, respectively. When the citation analyzes of the journals were evaluated, the most influential journals according to the average number of citations per article they published were American Journal of Respiratory and Critical Care Medicine, American Review of Respiratory Disease, Thorax, Chest, European Respiratory Journal, Critical Care Medicine, and Intensive Care Medicine, respectively. Not surprisingly, the most preferred and most-cited journals on NIV are respiratory diseases and intensive care journals. These are also high impacted journals in their disciplines. This may guide authors who want to publish papers about NIV and reach more readers.

The most commonly used keywords were non-invasive ventilation, chronic obstructive pulmonary disease, continuous positive airway pressure, acute respiratory failure, and obstructive sleep apnea. This reflects the most frequently studied topics related to NIV, similar to Cortegiani’s study (19). Cluster network visualization map gave ideas also about other interested diseases. Chronic respiratory failure, obesity, cystic fibrosis, neuromuscular disorders, pneumonia, and weaning were seemed less popular but candidate issues for new studies.

According to our knowledge, this is the first comprehensive study that examined the dynamics of literature about NIV bibliometrically. Previously, Cortegiani and colleagues planned research with a similar curiosity and defined ten impressive articles published on NIV to identify research topics related to NIV. They stated that NIV use on COPD exacerbations has solid evidence and other issues need well-designed randomized studies. They also made a suggestion list for future studies (19).

Our study has the advantage of including approximately all studies since NIV started to be used. Besides, using comprehensive statistical methods such as keyword, cluster, correlation, and regression analysis improves the power of our research. We can say that it draws a detailed framework to the history of NIV.

We did not use the Pubmed index because it does not allow us to make citation and co-citation analyses. We also did not use the Scopus index because it includes studies with low effect levels. So, we used only the WoS index. This may be a limitation of our study. But, it should also be considered that WoS is more commonly preferred in bibliometric analyses conducted in recent years.

Conclusion

NIV technology and new devices are developing day by day. In addition, new areas of use have been defined by doctors. All these bring about new and different studies on NIV. We believe the present study which summarized the history and development of NIV literature, will guide the authors who want to study this area.

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