MODIFICATION OF BAG VALVE MASK BASED ON BIBLIOMETRIC REVIEW AND ANALYSIS

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ABSTRACT

A bag valve mask (BVM) is a tool that provides basic life support measures for ventilation assistance. The effectiveness of providing ventilation assistance can be influenced by the accuracy of the timing of ventilation to minimize the risk of hyperventilation. This study aims to analyze current research themes and trends in the global use and adaptation of BVMs. The research design used descriptive analysis with a bibliometric analysis approach through the Publish or Perish and VosViewer applications. The article search period used was 2000-2023 from the Scopus and PubMed databases and continued with a trend analysis of the topics studied. The results of article searches that have been carried out on the Publish or Perish application obtained 193 articles that discuss BVM since 2000-2023 based on the Scopus and Pubmed databases. There are 3 clusters of research topics, namely, the comparison of the use of BVM with other tools in the ventilation or oxygenation process, the use of BVM in the intubation or induction process, and research related to the effectiveness of BVM tools modified with different techniques or shapes. According to the results of the bibliometric analysis, 193 articles are related to the topic of BVM. Currently, research on BVMs consists of comparison, effectiveness of use, and process actions that involve BVMs. However, research has yet to be conducted on BVM modification. This is a great opportunity for researchers to conduct innovative research to develop BVM with various facilities that can support it.

Keywords:
Bag valve mask, Bibliometric, BVM

BACKGROUND

A Bag Valve Mask (BVM) is a medical device used for first aid in patients with cardiopulmonary arrest or patients with inadequate breathing to provide positive pressure ventilation for adequate oxygenation (Alarga, 2023; Culbreth, 2021; Lee, 2023). The BVM comprises several components, such as an expandable bag, a directional valve, and a mask for the patient's face.

A firm grasp of Basic Life Support (BLS) principles is crucial when administering assisted ventilation with a BVM. BLS entails a series of emergency procedures used to address respiratory or cardiovascular issues in patients. This essential skill is imperative for healthcare professionals across the globe to possess (Edelson, 2020; Panchal, 2020). In the concepts and principles of BLS, the use of BVM is carried out when there are indications of cardiac-respiratory arrest, respiratory arrest, and ineffective breathing in patients who are given help (Fitzpatrick et al., 2018; Wirmando, 2023). In accordance with the guidelines for the management of Out of Hospital Cardiac Arrest (OHCA) issued by the American Heart Association (AHA) for the COVID-19 pandemic, respiratory assistance should only be carried out using assistive devices such as bag valve masks, and strictly prohibits the provision of respiratory assistance with mouth-to-mouth techniques (American Heart Association, 2020; Panchal, 2020). The use of BVM in BLS actions, especially in the event of Out of Hospital Cardiac Arrest (OHCA), provides a 4% higher chance of Return of Spontaneous Circulation (ROSC) compared to Endotracheal Intubation (ETT) (Yuksen, 2020). The same condition was shown by Idris et al. (2023), who explained that the use of BVM during cardiopulmonary resuscitation (CPR) in 1976 patients with a ratio of 30 compressions and 2 ventilations had a higher chance of experiencing ROSC in 40.7% of patients, survival to hospital discharge in 13.5% of patients, and survival with good neurological condition in 10.6% of patients. This evidence shows that BVM is important in basic life support measures, especially CPR.

Proper technique can significantly impact the volume, pressure, and airflow during BVM utilization (Fitzpatrick et al., 2018; Khoury, 2016). It is important to adhere to specific procedures to optimize the effectiveness and efficiency of BVM usage during rescues. These may include proper patient positioning, infection control measures, utilization of additional airways such as an Oropharyngeal Airway (OPA), utilization of bacterial filters, compressing the BVM bag to ¾ capacity, and adjusting ventilation rhythm to align with the patient's physiology (Cierniak, 2018; Strzelecki, 2020). However, rescue workers often do not pay attention to the quality of breath support using BVMs.

Improper use of the BVM can cause severe harm to the patient. When employed ineffectively in Basic Life Support (BLS), it can lead to critical conditions like hypoxia or hypercapnia due to insufficient ventilation. Additionally, Gastric Insufflation can occur, resulting in abdominal distension and an increased risk of aspiration. Finally, barotrauma can result from excessive positive pressure during BVM ventilation, damaging lung tissue (Dodds, 2023; Vemuru, 2022). A study explained that there was an incidence of hyperventilation in the BLS process using BVM as much as 79% worldwide, which had a risk of having a negative impact on patients who were helped (Culbreth, 2021). Therefore, to reduce hyperventilation when using a BVM during BLS, an innovative tool is necessary to assist helpers in the proper use of the BVM.

Innovation in nursing is based on Locsin's nursing theory, which focuses on the integration between technology and care in nursing practice. This theory brings concepts that reflect the importance of technological competence as an integral part of caring in nursing (Hansen & Dysvik, 2022). In the concept of Locsin's theory, innovation is based on the process of health control to achieve more effective and efficient nursing goals by taking into account aspects of patient health and nurse health, quality control to achieve quality standards in nursing, and cost control in reducing practice expenses to accelerate decisions in controlling nursing performance (Singleterry, 2020).

Innovation can involve updating existing things with additional features or creating something new to support an activity. In BLS procedures, there is a risk of hyperventilation that can harm the patient's health (Costello, 2017; Mekonnen, 2020; Simon, 2016). Researchers are exploring the possibility of incorporating a portable indicator light into the BVM to mitigate losses resulting from user error. This innovative solution aims to serve as a prompt for helpers to provide ventilation while pumping the BVM. The study is intended to analyze current research themes and trends in the global use and adaptation of BVMs.

Based on established procedural theories for optimal usage of the BVM, portable indicator lights have been implemented to aid in the ventilation process. These lights emit a signal through a calibrated flame that aligns with the 5-6 second per cycle BVM

procedure (Bennett, 2020). It is hoped that the indicator light can help the user determine the correct ventilation rhythm when using BVM, thus minimizing negative impacts resulting from ineffective BVM use during the BLS process.

Research related to BVM has been conducted among many researchers worldwide. Various themes and research topics in health aspects are related to utilizing BVM in every action. Various themes and research topics in health aspects are related to utilizing BVM in every action. However, the development of science always provides opportunities for researchers to conduct the latest research, especially those related to BVM. Based on the explanation, this study aims to analyze current research themes and trends in the global use and adaptation of BVMs.

METHODS

A descriptive analysis design was employed to conduct this research. The methodology used involved utilizing a bibliometric analysis approach, which allowed for a thorough examination of the relevant literature and data. The primary objective of this study is to examine scientific publications related to BVM. Our article search process involved utilizing the Publish or Perish application in conjunction with the Scopus database and Pubmed. Only articles that were directly linked to the keyword "Bag Valve Mask" and were published were considered for this study.

The instrument used in this research is a scientific article search application that is integrated with the article database. The application used is called Publish or Perish. The process of using this application is: 1) determine the database, which in this study uses the Scopus and Pubmed databases; 2) determining the period of the article search; in this case, the researcher applies 2 search periods, namely 2000-2010, and 2011-2023; 3) determining keywords related to the search for article topics, the researcher uses the keyword "Bag Valve Mask" and "Modification" or "Innovation"; 4) performing article searches; 5) saving search results with Research Information System (RIS) data format.

The article collection process has been carried out since August 2023 using the Publish or Perish application. Data analysis in this study used the VosViewer_1.6.18 application. The data analysis process with this application is carried out to determine the distribution of topics related to the keywords that have been determined. In addition, this application allows researchers to find the latest topic trends according to the article data obtained.

RESULTS

Based on the data extracted by the Publish or Perish application in Table 1, a search for articles within a specific timeframe generated 193 publications. Notably, the year 2000-2023. 2020 recorded the highest number of articles published, with 19 articles accounting for 9.84% of the total publications between 2000-2023. The following was from 2006 and 2018, with 16 (8.29%) and 14 (7.25%) articles, respectively.

Based on Figure 1, it is known that the trendline shows an increase in the number of publications from 2000-2023. This concerns the progress of science and technology, specifically in emergency care for patients requiring additional ventilation with a BVM. With a growing number of published works each year, our understanding of BVM as a Basic Life Support (BLS) tool continues to expand.

When conducting research on scientific articles, selecting the appropriate keywords is crucial. Our team analyzed 193 articles using VosViewer and identified several BVM-related keywords, which we classified into 3 color-coded clusters. Figure 2 reveals that of the 193 articles, three keywords emerged as the most popular and relevant: comparing BVM with alternative tools, investigating the efficacy of BVM when combined with various techniques or forms, and employing BVM during intubation/oxygenation/induction processes. Based on these findings, we can conclude that research has yet to be conducted since 2023 on modifying the BVM tool to create an innovation that could aid with manual ventilation, particularly rescue breathing in BLS.

Determining the relevance of research findings to current situations relies heavily on knowing the year of publication. Figure 3 categorizes research topics by their year of publication, with the brightness of each dot indicating its recency. Based on the figure, hospital cardiac arrest and manual ventilation are current topics prominently featured in BVM-related research. This suggests that researchers still have untapped potential to investigate modifications or innovations in BVM tools, as the topic has yet to be extensively studied.

By conducting a bibliometric analysis, changes in topic terms in a study can be identified. Figure 4 displays frequently occurring terms in articles analyzed using VosViewer, categorized by the color around the topic. The brighter the color, the more frequently the topic appears in a study. Based on Fig-

Table 1. Article Distribution in the Period 2000-2023

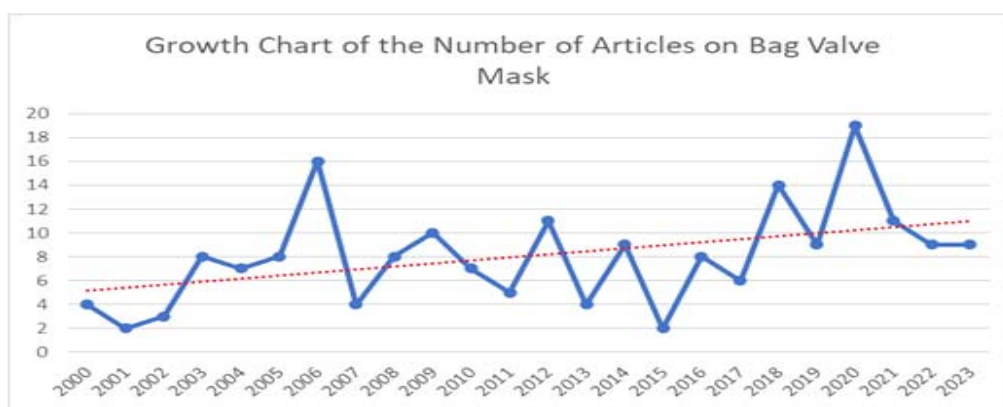| Year	Total Articles	Percentages (%)
2000	4	2.08
2001	2	1.04
2002	3	1.56
2003	8	4.14
2004	7	3.63
2005	8	4.14
2006	16	8.29
2007	4	2.08
2008	8	4.14
2009	10	5.19
2010	7	3.63
2011	5	2.60
2012	11	5.69
2013	4	2.08
2014	9	4.66
2015	2	1.04
2016	8	4.14
2017	6	3.11
2018	14	7.25
2019	9	4.66
2020	19	9.84
2021	11	5.69
2022	9	4.66
2023	9	4.66
Total	193	100

Figure 1. Growth Chart of the Number of Articles on Bag Valve Mask

ure 4, it is evident that the topic terms that commonly appear in research using BVM keywords are cardiopulmonary resuscitation (CPR), comparison, bag, and BVM device. These results suggest that modifying the topic term on BVM has not been explored in research and presents a novel opportunity for researchers.

DISCUSSION

A recent study has noted that there has been a gradual growth in studies related to BVMs over the past two decades. Nonetheless, the development of BVM tools could be more active. As a result, a significant prospect exists for researchers globally to
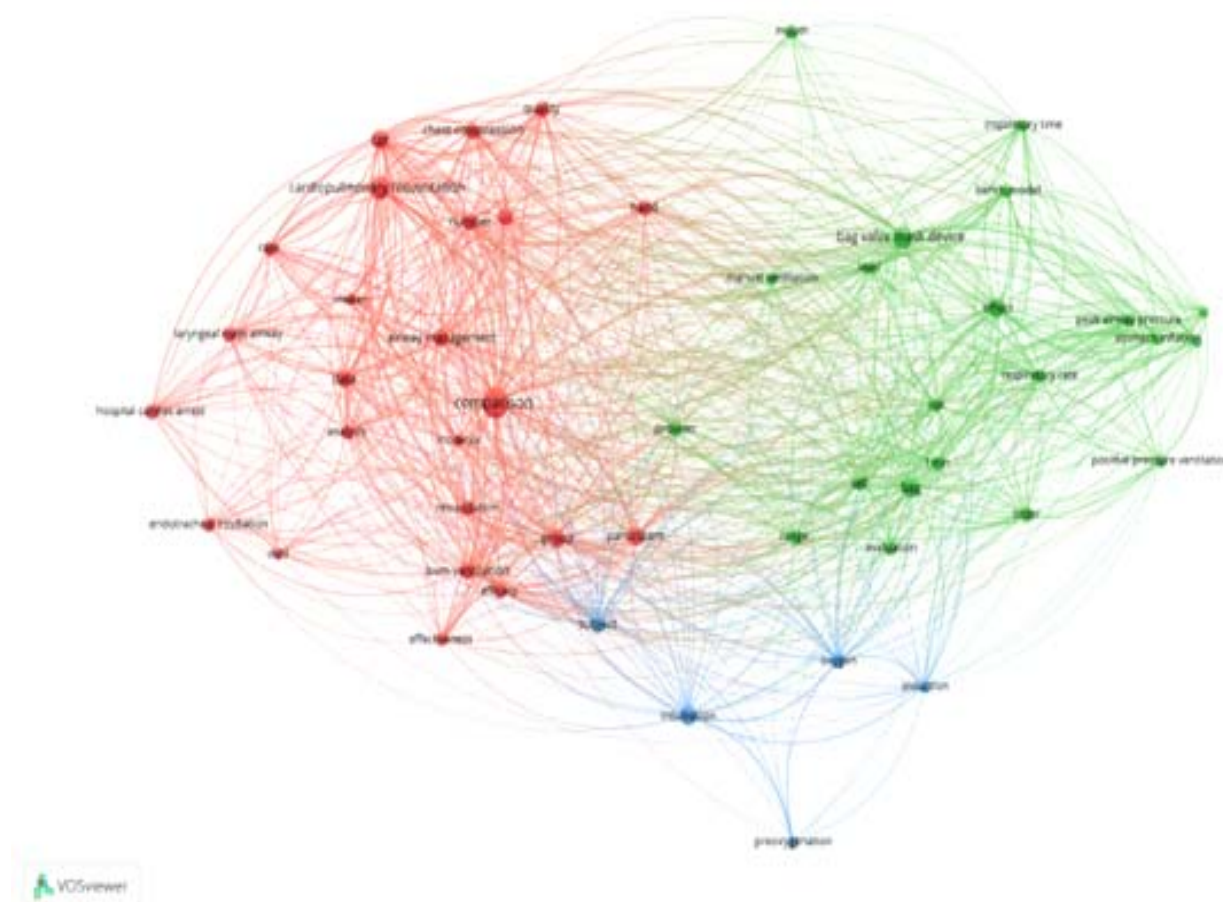
Figure 2. Visualization Network Bag Valve Mask Research Title Period 2000 - 2023

concentrate on enhancing BVM technology.

In order to gain insight into the evolution of research topics related to specific keywords, it is essential to analyze articles published between 2000 and 2023. In the early 20th century, positive pressure ventilation was the primary focus of researchers. However, as time progressed, additional studies explored BVM's potential for managing heart attacks in hospital settings. By utilizing the VosViewer application for analysis, it becomes evident that research related to BVM is centered around three main themes. The red cluster shows that research on BVM includes a discussion of its use compared to other methods. In a study by L. Davidovic 2005 with 52 citations, he examined the effects of using one or two helpers to provide respiratory assistance with BVM in infants and children. The results showed that using two helpers produced a greater tidal volume during ventilation than using one helper (Davidovic, 2005). In his publication, Simon M. compares High Flow Nasal Canul (HFNC) and BVM for preoxygenation and oxygenation assessment during intubation in patients with respiratory failure and hypoxemia. The study highlights that HFNC is a safer and more effective alternative for intubation in patients than BVM (Simon, 2016). Numerous research studies conducted in the red cluster have examined the application of BVM. However, these studies have not compared the standard BVM with its modified versions. Therefore, there is a scope for novel research to investigate the efficacy of BVMs with added features.

Researchers are currently emphasizing the intubation, induction, preoxygenation, and oxygenation process using BVM, as evidenced by the blue cluster. J. Watcharotayangul's research delved into applying BVM with mechanical filters in oxygenation, utilizing proximal oxygen to address hypoxemia patients. The study's results demonstrated that incorporating proximal oxygen to the BVM with a mechanical filter proved effective in facilitating preoxygenation for patients experiencing hypoxemia (Watcharotayangul, 2023). Employing a BVM during oxygenation, preoxygenation, intubation, and induction procedures is essential. This is because adequate oxygenation is necessary for patients to sustain their metabolism, and the BVM can mechanically deliver oxygen flow to assist their respiratory system. This is vital in emergencies, allowing patients
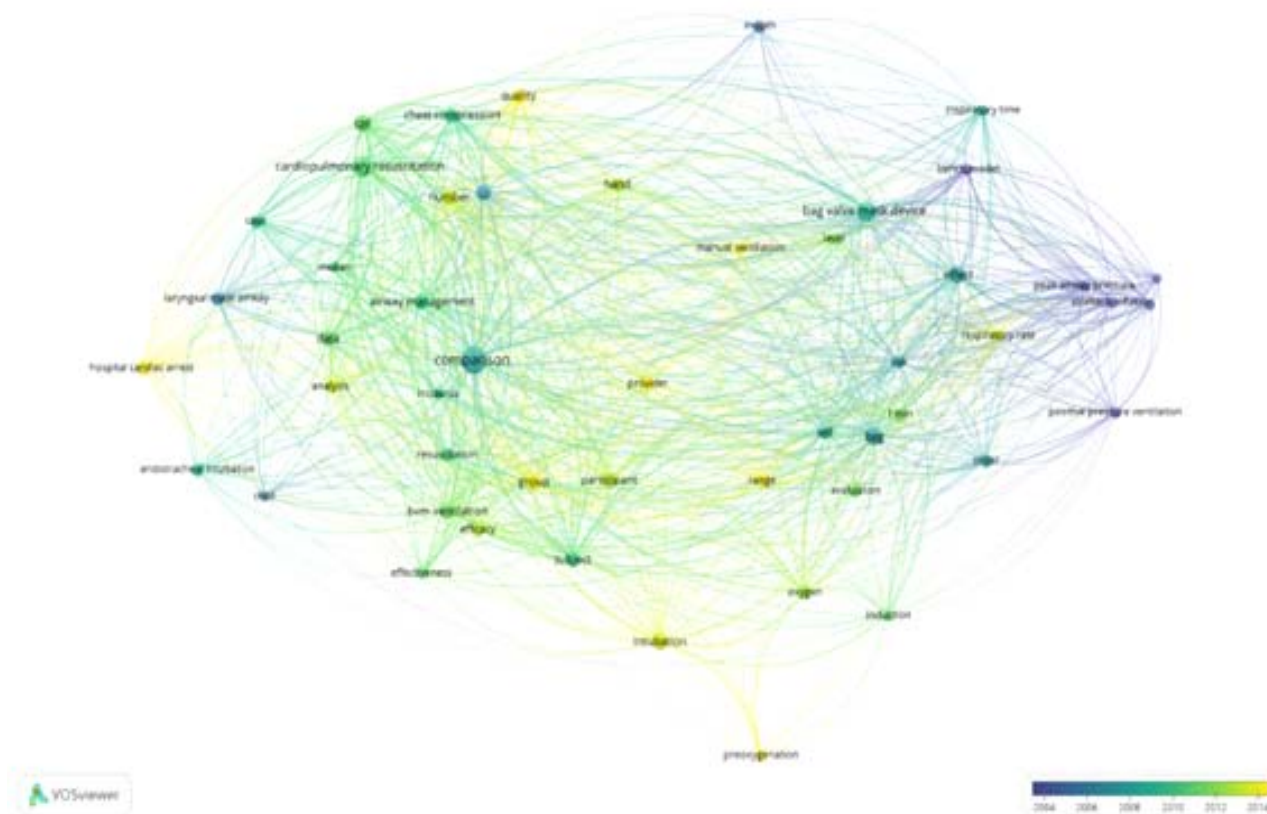
Figure 3. Visualization Overlay Bag Valve Mask Research Title Period 2000 - 2023

to survive (Dai, 2021). However, there are several risks associated with a mechanical system controlled entirely by humans, such as user negligence or lack of skill, which can adversely impact the patient's health (Houck, 2020).

The individual conducting research within the green cluster aims to delve deeper into the BVM Device. Their focus lies on studying the efficacy of varying hood sizes used with the BVM, as well as the influence of different grips on BVM bags, about maximizing the flow of air. M. Kroll's 2019 study explored the impact of diverse BVM bag grips on airflow volume, revealing that altering the grip directly affected the amount of air delivered. Generally speaking, pediatric BVM volumes exhibited more consistent airflow than adult BVM volumes (Kroll, 2019). A study conducted by J. Siegler in 2017 evaluated the efficacy of using a pediatric BVM for ventilation in adult patients. The results demonstrated that utilizing a smaller BVM size for pediatrics effectively ventilated adult patients. This is due to the consistent level of airflow provided by pediatric BVMs (Siegler, 2017).

Upon conducting a thorough analysis through VosViewer, it was discovered that no existing studies are currently exploring the modification of BVM to support rescue operations better. Nevertheless, the recent introduction of the ventilation time indicator light presents an opportunity for further investigation that could potentially lead to an improved tool for assisting patients needing BLS intervention.

The innovation process in BVMs with portable indicator lights closely relates to Locsin's nursing theory. This theory brings a nursing paradigm that integrates the concepts of health control and quality to focus on the role of innovation in achieving practical nursing goals (Krel et al., 2022). In Locsin's Theory, there is an emphasis on the importance of integration between technology and nursing practice. This shows that any technology created should be used to improve the efficiency and effectiveness of nursing actions without overriding the human aspect (Bahari et al., 2021; Krel et al., 2022). The innovation of BVM with portable indicator lights is intended to provide high-quality ventilation actions in BLS. Thus, this innovation is expected to help victims who need BLS by minimizing the negative impacts that may arise by providing additional ventilation (Calilung
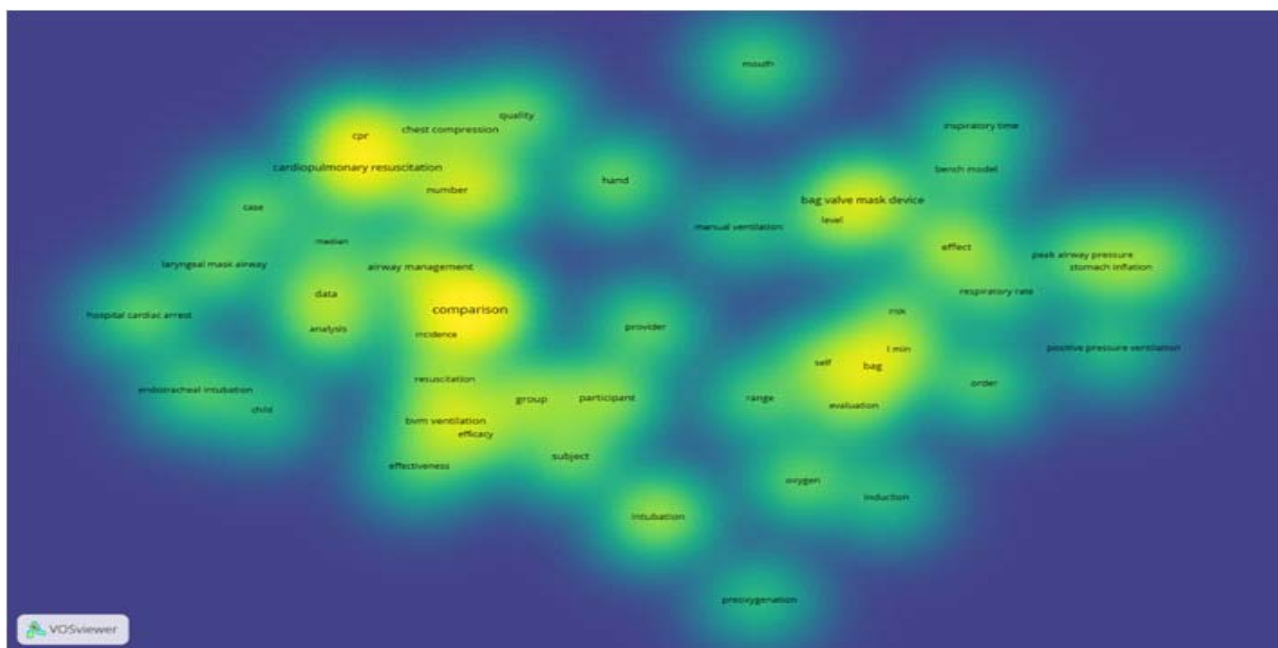
Figure 4. Visualization Density Bag Valve Mask Research Title Period 2000 - 2023

et al., 2020).

The development of BVM with portable indicator lights cannot be separated from the role of nurses as the main component. Nurses, as direct users of this tool, have an important role in identifying needs, analyzing problems, and developing practical solutions to support the nursing process, especially in emergency nursing (Whiteman et al., 2021). Nurses, through this innovation process, assist in developing a more effective and efficient BVM tool. By integrating portable indicator lights, it is possible to provide direct ventilation control during BLS. Nurses with technical and humanitarian competence assisted in developing a device that meets health and quality standards while considering ergonomics and safety aspects for patients and caregivers. Nurses also assist in developing tools that enable nursing controllers to control nursing performance efficiently, reduce the risk of fouling and lack of information, and speed up the decision process in controlling nursing performance. With their technical and humanitarian competencies, nurses assist in developing tools that meet health and quality standards while considering ergonomics and safety aspects for patients and caregivers (Isidori et al., 2022).

This study is significant because it represents the first instance of bibliometric analysis employed within the BVM field, providing valuable insight into current trends and advancements. However, it is important to note that the scope of this study was limited by the databases utilized (Scopus and PubMed) from 2000-2023, which may only encompass some pertinent topics related to BVM research. Further research is therefore warranted to address and refine these constraints.

CONCLUSION

The Bag Valve Mask (BVM) is a mechanical device that helps patients with respiratory disorders or cardiac arrest receive ventilation or oxygenation. Despite its importance, research on BVM is limited, with only 193 scientific articles published between 2000 and 2023. Topics commonly explored in BVM research include comparisons with other ventilation devices, use during intubation or induction, and modified BVM devices with different techniques or shapes. A novel idea that could arise from BVM research is incorporating ventilation time indicator lights. Bibliometric analysis is helpful for researchers seeking to identify the latest research topics. Focusing on BVM modifications can improve effectiveness for those interested in modifying medical devices, particularly those used in Basic Life Support (BLS).

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