E-Cigarette Smoking Behavior: A Review and Bibliometric Analysis

Winda Widyanty and Dian Ayubi

Public Health Faculty, University of Indonesia, Jakarta, Indonesia

Abstract: **Purpose -**This study aims to analyze journal articles on e-cigarette smoking behavior to identify publication trends, impactful authors, leading journals, and most influential articles in this field. This study also conducted a knowledge structure analysis to map the knowledge base of articles, including their conceptual, intellectual, and social structures. Furthermore, the study proposes guidelines for further research in the future. **Design/methodology/approach -**Bibliometric techniques were used to analyze 290 out of 361 articles on e-cigarette smoking behavior indexed in Scopus published between 2007 and 2024 as a sample dataset. This study uses the Bibliometrix R package with the Biblioshiny application to generate bibliometric analysis and result visualizations. Three bibliometric methods, namely social network analysis, co-citation analysis, and co-occurrence clustering, were further conducted to sketch the contours of the structure and evolution of e-cigarette smoking behavior. **Findings -**Based on the analysis of 290 published articles, this study found that research on e-cigarette smoking behavior has increased over the past decade. This study highlights bibliographic elements such as impactful authors, leading journals, and most influential articles. Furthermore, this study reveals the knowledge structure, both conceptual, intellectual, and social structures.This study also highlights the importance of longitudinal studies as further research to understand how e-cigarette smoking behavior develops over time and what factors are most influential among the factors that have been identified in previous studies. **Research limitations/implications -**This study conducted a knowledge mapping of research on e-cigarette smoking behavior that can close the gap in the literature. In addition, the findings of this study highlighted many factors that influence e-cigarette smoking behavior that can be used as guidelines in developing more effective and efficient health promotion strategies. However, this study is limited to only one database and ignores the contribution of non-English language articles so that research with a wider scope is needed. **Originality/value -**This study provides a comprehensive view of the knowledge structure of studies on e-cigarette smoking behavior that can enrich the existing literature and can be used as a guide for future research and to develop more effective and efficient health promotion strategies.

Keywords: E-Cigarette, Smoking Behavior, Electronic Cigarette.

INTRODUCTION
BACKGROUND

Electronic cigarettes (e-cigarettes) are rapidly becoming a popular substitute for traditional tobacco cigarettes (Gordon, T., *et al*., 2022). This substitution appears to be driven by smokers' health concerns, the rising cost of tobacco cigarettes, and indoor smoking restrictions (Wang, R.J., *et al*., 2021). Numerous surveys and studies have shown that a significant number of smokers are significantly reducing their tobacco use and/or switching completely from tobacco cigarettes to e-cigarettes (Marques, P., *et al*., 2021).

Across age groups, young adults (18–29 years) tend to show the highest prevalence of e-cigarette use (Bennett, B.L., *et al*., 2017). Although most smokers begin smoking during adolescence, young adulthood is the period when researchers transition to regular use and develop nicotine dependence (Sun, T., *et al*., 2021). Young adulthood is also a period that facilitates persistent or occasional smoking (Creamer, M.R., *et al*., 2021), both of which are unsafe. In addition to the possibility that intermittent smokers may exhibit increased nicotine dependence, intermittent smoking exposes individuals to carcinogens and causes adverse physiological consequences (Stanton, C.A., *et al*., 2022).

Research shows that smokers who quit smoking before age 30 nearly eliminate their risk of death from cigarette-related causes, both e-cigarettes and conventional cigarettes. Therefore, smoking prevention and cessation efforts targeting young adults are important. Traditionally, primary prevention efforts related to smoking behavior have focused largely on adolescents and have utilized mass media and school and community settings (Cantrell, J., *et al*., 2020). This is understandable given that most smoking initiation occurs during adolescence. However, primary and secondary prevention efforts focused on young adults are less common. This is especially concerning because the e-cigarette industry has been known to strategically market its products to promote e-cigarette use among young adults by integrating e-cigarette use into activities and settings relevant to young adults (Kwon, E., *et al*., 2018).

The rapid development of science and technology has led to a sharp increase in scientific literature resources, and it has become increasingly challenging to sort and analyze the huge amount of literature data. Bibliometrics takes the literature system as the research object, uses statistical analysis, network analysis, and graph theory to study the quantitative relationship, distribution

*Corresponding Author: Winda Widyanty

structure, and change law of the literature corpus, discusses the internal structure of scientific literature, uses quantitative indicators to reflect its quantitative characteristics and regulations, and reveals the internal correlation of resources (Donthu, N., *et al*., 2021). Compared with narrative reviews, bibliometric assessment is more objective. Compared with systematic reviews, bibliometric methods concentrate on relatively general aspects, such as countries, institutions, authors, and research centers, rather than specific perspectives. Bibliometric studies can provide a quantitative overview of a research area. It includes cluster analysis of countries and institutions' collaboration areas, citation analysis of literature, co-citation analysis, co-authorship analysis, and keyword analysis. Based on bibliometric techniques, it can explore current research areas and potential future research directions to inform further research (Briganti, M., *et al*., 2019). Bibliometric analysis can help researchers understand the main focus of the field (Wang, J., *et al*., 2021). Currently, more and more bibliometric analysis articles are published in various journals. However, there is still no analysis on e-cigarettes. Therefore, a bibliometric analysis of e-cigarette use behavior was conducted to identify the journals and countries where the literature was published, the institutions that published the articles, the authors, the keywords, and the distribution of references of these papers. Our second goal is to find out the study trends in this emerging field and find some hotspots to guide future investigations.

Research Objectives

This study aims to analyze journal articles on e-cigarette smoking behavior contained in the Scopus database. This study attempts to provide a comprehensive overview of current research in the field of e-cigarette smoking behavior. The analysis in this study includes publication trends, identification of academics or researchers, journals, and important articles that have influence in this field. Furthermore, knowledge structure mapping is carried out in this study which consists of conceptual, intellectual, and social structures. Ultimately, this study will identify research gaps that can be used as a focus in future research.

RESEARCH METHOD
Article Searching
This study only uses one online database in searching for articles, namely Scopus. Scopus is a comprehensive abstract and citation database for academic journal articles. Scopus is widely used by many academics ranging from literature searches for scientific journals and reference books such as Chand, BR, & Hosseinzadeh, H. (2022), Olson, CK, *et al*., (2023) and Martins, BNFL, (2022).

The article search was conducted in the Scopus database using the terms "smoking behavior" AND "e-cigarette" OR "electronic cigarette" in the article title or among the keywords. The use of these search terms is based on previous studies related to e-cigarette smoking behavior. This initial search was conducted on October 6, 2024 and resulted in 361 documents. Significant growth has occurred over the past decade, starting in 2014 (figure 1).
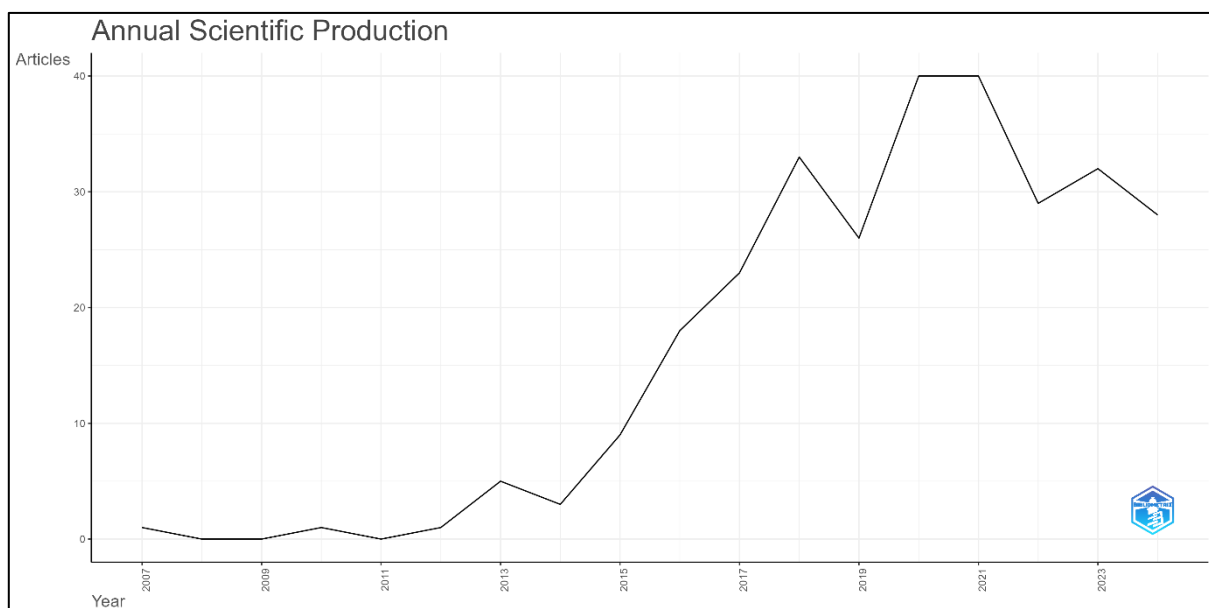
Figure 1: The annual number of articles published on e-cigarette smoking behavior

Article Screening

Not all articles in the Scopus database that match the term are analyzed, several restrictions are imposed in order to meet the objectives of writing this article. The first restriction, articles that are filtered to obtain articles that are complete research, not review articles or reference books. The goal is to obtain complete information and find gaps in previous research. And the second restriction is that the document is written in English. This is associated with the limitations of the author's language skills so that this restriction allows the author to better understand the contents of the article (Xu, Y., *et al*., 2022). In addition, in the initial search, the majority of documents use English. The third restriction is the restriction of articles that are in the final publication stage which is intended to avoid further changes related to the contents of the article during the process towards publication (Rakhmawati *et al*., 2024). This screening process resulted in 290 articles from a total of 361 articles.
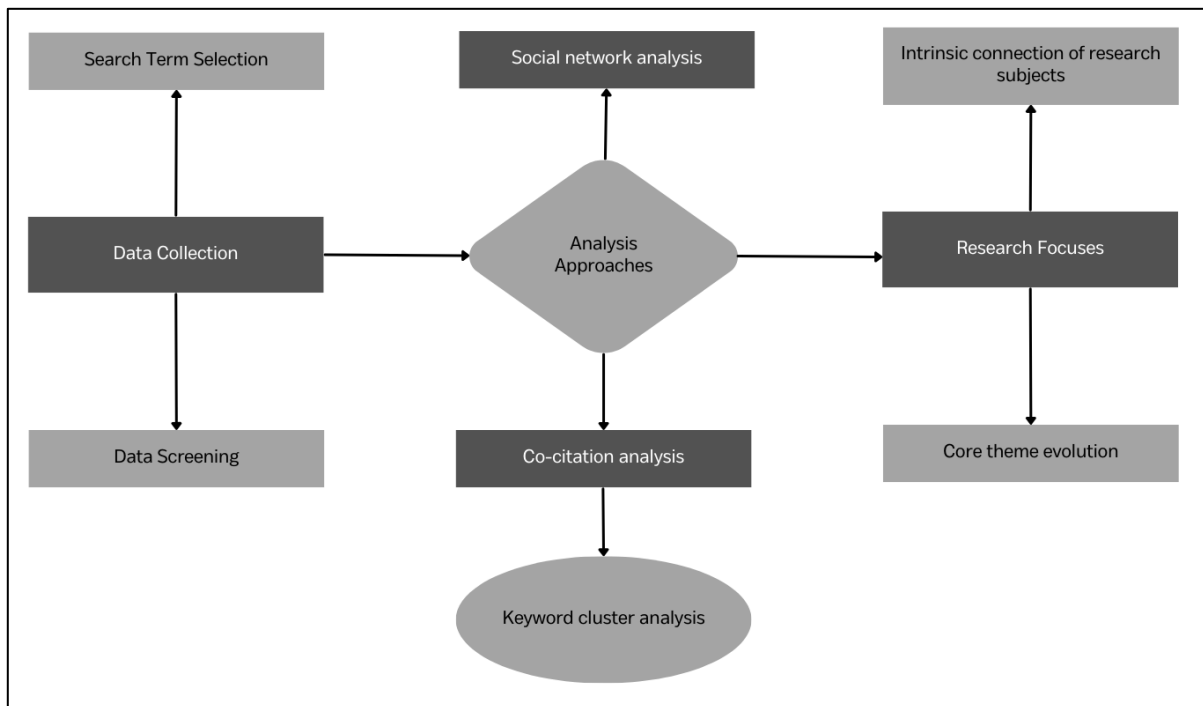
Figure 2: The research framework of this study

Data Analysis

This study adopts the bibliometric analysis method. Bibliometric analysis has become an important tool for evaluating various scientific elements such as papers, authors, keywords, journals, institutions, and countries in any research field (Donthu *et al*., 2021). This analysis is also used to track how the intellectual, social, and conceptual structures of a relevant field have evolved over time based on the relationships and interactions between these elements (Donthu *et al*., 2021). Conducting a bibliometric study is essential to map the progress of existing knowledge on a particular topic and identify areas that require further investigation (Rodríguez-Ruiz *et al*., 2019). This study uses the Bibliometrix R package with the Biblioshiny application to generate bibliometric analysis and visualize the results. The bibliometric analysis includes publication trends and performance analysis including impactful authors, leading journals, and most influential articles. Furthermore, this study conducts a knowledge structure analysis to map the knowledge base of articles, including their conceptual, intellectual, and social structures.

RESULT AND DISCUSSION

Research Trends

Analysis of 290 datasets shows that articles on e-cigarette smoking behavior began to develop since 2007 with the first article by Smith, SY, *et al*., (2007) entitled "Harm perception of nicotine products in college freshmen". In the early period since the first article was published, scientific publications on the topic grew quite significantly. The annual article growth rate was 21.65% with an average article age of 4.21 years. The significant increase in scientific publications in the period

Widyanty, W. and Ayubi, D.

Sarc. Jr. int. med. Pub. Heal.vol-3, issue-06 (2024) pp-12-27

2014 to 2022 shows that e-cigarette smoking behavior is currently getting more attention from academics.

Table 1. provides key information about the dataset used in this study. A total of 145 journals were used as media to publish articles on e-cigarette smoking behavior involving 1,366 authors. Each article involved an average of 5.34 co-authors, while 12 articles were written by 9 single authors with an average citation per article of 18.67. The total number of keywords used by the author to identify the topics discussed was 575. While the total number of references used in writing 290 articles was 10,584.

Table 1: Main Information

Description	Results
Documents (Articles)	290
Sources (Journal)	145
Timespan	2007:2024
Annual Growth Rate %	21.65
Document Average Age	4.21
Average citations per doc	18.67
Authors	1,366
Authors of single-authored docs	9
Single-authored docs	12
Co-Authors per Doc	5.34
Author's keywords	575
References	10,584

Performance Analysis
Impactful Authors
Articles related to e-cigarette smoking behavior are still in the early stages of development. This can be seen from the number of documents and citations produced by the authors. Table 2 presents the authors who most frequently publish articles on e-cigarette smoking behavior, where there are ten authors who have at least one publication on e-cigarette smoking behavior. The most productive author is Cao D with 6 publications from 2016 to 2021. Followed by Park EC with the same number of articles but started writing in 2018. Next there isGoniewicz ML and King AC with a total of 5 articles, the rest are authors with a total of 4 articles, namely Jang SI, Caponnetto P, Maglia M, Miloslavich K, Polosa R.

Several metrics are used to assess the impact of articles published by authors, such as total citations (TC), H_Index, G_Index, and M_Index. Global citations (TC) refers to the number of citations an article receives from documents indexed in bibliographic databases such as Scopus, WoS, etc., effectively counting the citations a selected article receives "worldwide". Meanwhile, H-index, G-index, and M-index are indicators of the relevance of a scientist's work. This assumes that the number of citations a scientist receives is a better indicator of the relevance of their work than the number of papers published or the journals in which the papers appear (Hirsch and Buela-Casal, 2014).

Based on the analysis results, Cao D and Park EC are the authors with the most publications related to e-cigarette smoking behavior. WhileCaponnetto P, Maglia M, and Polosa R are the authors with the most citations, namely 160 citations. They are also the earliest authors to discuss and publish articles on e-cigarette smoking behavior compared to other authors who have an impact. Furthermore, the largest H-index is occupied by Cao D and Goniewicz ML, while the G_index is occupied by Cao D and Park EC. The highest M_index is occupied by Miloslavich K, followed by Park EC and Jiang SI.

Table 2: Authors' Production over Time and Their Local Impact.

Author	Documents	h_index	g_index	m_index	TC	PY_start
CAO D	6	5	6	0.556	103	2016
PARK EC	6	4	6	0.571	67	2018
GONIEWICZ ML	5	5	5	0.5	122	2015
KING AIR CONDITIONER	5	4	5	0.444	87	2016
JANG SI	4	4	4	0.571	58	2018
CAPONNETTO P	4	4	4	0.364	160	2014
MAGLIA M	4	4	4	0.364	160	2014
MILOSLAVICH K	4	4	4	0.8	24	2020
PLAIN R	4	4	4	0.364	160	2014
SHAHAB L	4	4	4	0.4	93	2015

Leading Journals

Scientific journals are used by researchers to disseminate their research findings. Table 3 presents a list of the most productive journals that publish articles on e-cigarette smoking behavior and its impacts. The analysis found that 145 journals published scientific articles on the topic. The International Journal of Environmental Research and Public Health is the journal that published the most articles related to e-cigarette smoking behavior, which is 17 articles, followed by the journals Nicotine and Tobacco Research, Addictive Behaviors and BMC Public Health with 16 articles. Tobacco Control published 11 articles while BMJ open and Drug and Alcohol Dependence published 8 articles related to e-cigarette smoking behavior. In the last position are the journals Plos One and Preventive Medicine which published 7 and 6 articles related to e-cigarette smoking behavior.

Furthermore, Tobacco Control is the journal with the most impact as seen from the largest number of citations among other journals, which is 815 citations, followed by Nicotine and Tobacco Research with 565 citations, and BMC Public Health with 319 citations. Meanwhile, as seen from the h_index, Nicotine and Tobacco Research is in first place followed by Addictive Behaviors. The highest g_index is occupied by BMC Public Health and Nicotine and Tobacco Research followed by Addictive Behaviors. While for m_index, the first place is occupied by the International Journal of Environmental Research followed by BMC Public Health.

Table 3: The journal outlets with the highest number of relevant publications

Source	NP	h_index	g_index	m_index	TC	PY_start
International Journal Of Environmental Research And Public Health	17	7	12	0.778	170	2016
Nicotine And Tobacco Research	16	11	16	0.611	565	2007
Addictive Behaviors	16	10	13	1,429	191	2018
Bmc Public Health	16	8	16	0.727	319	2014
Tobacco Control	11	8	11	0.667	815	2013
Bmj Open	8	6	8	0.5	96	2013
Drug And Alcohol Dependence	8	6	8	0.6	186	2015
Plos One	7	5	7	0.455	99	2014
Preventive Medicine	6	4	6	0.5	91	2017
Psychology Of Addictive Behaviors	4	4	4	0.444	110	2016

The Most Influential Articles

Table 4 shows the most cited articles globally. Total Citation (TC) shows the total number of citations received by the article, based on TC calculations, the most influential article globally is "Electronic nicotine delivery systems: adult use and awareness of the 'e-cigarette' in the USA" written by Regan, AK, *et al*., (2013) with a total of 405 citations. The second most influential article is an article entitled Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii written by Wills, TA, *et al*., (2017) with a total of 237 citations. The next influential article is an article written by Hammond, D., *et al*., (2017) entitled "Electronic cigarette use and smoking initiation among youth:

a longitudinal cohort study" with a total of 126 citations.

The three articles discuss e-cigarette smoking behavior from different points of view. Regan, AK, *et al*., (2013) conducted a survey of 10,587 consumers in 2009 and 10,328 consumers in 2010 who were over 18 years old to monitor awareness, ever use and past month use of ENDS from 2009 to 2010 and to assess demographic characteristics and tobacco use of ENDS users. In this US sample, awareness of ENDS doubled from 16.4% in 2009 to 32.2% in 2010 and ever use more than quadrupled from 2009 (0.6%) to 2010 (2.7%). Ever use of ENDS was most common among women and those with lower education, although these were not the groups who had heard of ENDS most often. Current smokers and tobacco users were most likely to try ENDS. However, current smokers who have tried ENDS do not say they plan to quit smoking more often than smokers who have never tried them.

Furthermore, Wills, TA, *et al*., (2017) conducted a longitudinal study of 2,338 ninth and tenth grade students with a mean age of 14 years in Hawaii in 2013 (T1) and followed up 1 year later (time 2, T2) that assessed e-cigarette use, tobacco cigarette use, and psychosocial covariates (demographics, parental support and monitoring, and sensation seeking and rebelliousness). The study reported that Among T1 never-smokers, those who had used e-cigarettes at T1 were more likely to have smoked cigarettes at T2; for a complete-case analysis, adjusted OR=2.87, 95% CI 2.03 to 4.05, p<0.0001. Among ever-smokers at T1, using e-

cigarettes was not related to significant change in their frequency of smoking at T2. Uptake of e-cigarette use among T1 never-users of either product was predicted by age, Caucasian or Native Hawaiian (vs. Asian American) ethnicity, lower parental education and parental support, higher rebelliousness, and perception of e-cigarettes as healthier.

In line with the study conducted by Hammond, D., *et al*., (2017) which examined students in grades 9-12 who participated in 2 waves of COMPASS, a cohort study of purposefully sampled secondary schools in Ontario and Alberta, Canada, at baseline (2013/14) and 1-year follow-up (2014/15). This study assessed cigarette smoking and e-cigarette use at baseline and follow-up using self-completed surveys used generalized linear mixed-effects models to examine correlates of past 30-day e-cigarette use at baseline and smoking initiation between waves within the longitudinal samples. The study results show that Past 30-day e-cigarette use increased from 2013/14 to 2014/15 (7.2% v. 9.7%, p < 0.001), whereas past 30-day cigarette smoking decreased slightly (11.4% v. 10.8%, p = 0.02). Among the 44 163 students evaluated at baseline, past 30-day e-cigarette use was strongly associated with smoking status and smoking susceptibility. In the longitudinal sample (n = 19 130), past 30-day use of e-cigarettes at baseline was associated with initiation of smoking a whole cigarette (adjusted odds ratio [OR] 2.12, 95% confidence interval [CI] 1.68-2.66) and with initiation of daily smoking (adjusted OR 1.79, 95% CI 1.41-2.28) at follow-up.

Table 4: Most globally cited articles

Author	Article	Source	TC	TC/Year	NTC
Regan, A.K., Promoff, G., Dube, S.R. & Arrazola, R. (2013).	Electronic nicotine delivery systems: adult use and awareness of the 'e-cigarette' in the USA	Tobacco control, 22(1), 19-23.	405	33.75	2.79
Wills, T.A., Knight, R., Sargent, J.D., Gibbons, F.X., Pagano, I. & Williams, R.J. (2017)	Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii.	Tobacco control, 26(1), 34-39.	237	29.63	6.14
Hammond, D., Reid, J.L., Cole, A.G. & Leatherdale, S.T. (2017).	Electronic cigarette use and smoking initiation among youth: a longitudinal cohort study.	Cmaj, 189(43), E1328-E1336.	126	15.75	3.26
Coleman, B.N., Apelberg, B.J., Ambrose, B.K., Green, K.M., Choiniere, C.J., Bunnell, R. & King, B.A. (2015).	Association between electronic cigarette use and openness to cigarette smoking among US young adults.	Nicotine & Tobacco Research, 17(2), 212-218.	111	11.10	1.87
Audrain-McGovern, J.,	The impact of flavoring on the	Drug and	108	12.00	2.99

Strasser, A. A. & Wileyto, E. P. (2016).	rewarding and reinforcing value of e-cigarettes with nicotine among young adult smokers.	alcohol dependence, 166, 263-267.			
Al-Delaimy, W.K., Myers, M.G., Leas, E.C., Strong, D.R. & Hofstetter, C.R. (2015).	E-cigarette use in the past and quitting behavior in the future: a population-based study.	American journal of public health, 105(6), 1213-1219.	106	10.60	1.78
Barrington-Trimis, J.L., Berhane, K., Unger, J.B., Cruz, T.B., Urman, R., Chou, C.P., ... & McConnell, R. (2016).	The e-cigarette social environment, e-cigarette use, and susceptibility to cigarette smoking.	Journal of Adolescent Health, 59(1), 75-80.	98	10.89	2.71

Table 5 shows the most locally cited articles. The first rank is the article with the title "Association Between Electronic Cigarette Use and Openness to Cigarette Smoking Among US Young Adults" written byColeman, BN, *et al.*, (2015) with 9 citations. The article discusses the use of electronic cigarettes in young adults. The results of this study indicate that those who have a tendency to use electronic cigarettes are those who are male, aged 18-24 years, have low education, and have used shisha or tried conventional cigarettes.

The next most cited article is the article entitled "Does Vaping in E-Cigarette Advertisements Affect Tobacco Smoking Urge, Intentions, and Perceptions in Daily, Intermittent, and Former Smokers?" written byMaloney, EK, & Cappella, JN (2016) with 9 local citations. This article discusses the visual depiction of vaping in e-cigarette advertisements increases daily smokers' desire to smoke and can lead to more real smoking behavior in a study of 301 daily smokers, 272 intermittent smokers, and 311 former smokers. In contrast to the third article that received the most local citations, namely the article entitled "Electronic nicotine delivery systems: adult use and awareness of the 'e-cigarette' in the USA: written by Regan, AK, *et al.*, (2016) with 8 local citations. This article discusses the increase in awareness of e-cigarette use in 10,587 adults (≥ 18 years) in 2009 and 10,328 adults in 2010. This study recommends continued monitoring of e-cigarettes because of their impact on long-term health.

Table 5: Most locally cited articles

Author	Article	Source	Local Citations	Global Citation	LC/GC Ratio (%)	NTC
Coleman, B.N., Apelberg, B.J., Ambrose, B.K., Green, K.M., Choiniere, C.J., Bunnell, R. & King, B.A. (2015).	Association Between Electronic Cigarette Use and Openness to Cigarette Smoking Among US Young Adults	*Nicotine & Tobacco Research*, 17(2), 212-218.	9	111	8.11	3.68
Maloney, E. K. & Cappella, J. N. (2016).	Does Vaping in E-Cigarette Advertisements Affect Tobacco Smoking Urge, Intentions, and Perceptions in Daily, Intermittent, and Former Smokers?	Health communication, 31(1), 129-138.	9	79	11.39	6.75
Regan, A.K., Promoff, G., Dube, S.R. & Arrazola, R. (2013).	Electronic nicotine delivery systems: adult use and awareness of the 'e-cigarette' in the USA.	*Tobacco control*, 22(1), 19-23.	8	405	1.98	5.00

Wills, T.A., Knight, R., Sargent, J.D., Gibbons, F.X., Pagano, I. & Williams, R.J. (2017).	Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii.	*Tobacco control*, 26(1), 34-39.	7	237	2.95	10.06
Al-Delaimy, W.K., Myers, M.G., Leas, E.C., Strong, D.R. & Hofstetter, C.R. (2015).	E-cigarette use in the past and quitting behavior in the future: a population-based study.	*American journal of public health*, 105(6), 1213-1219.	6	106	5.66	2.45
King, A.C., Smith, L.J., Fridberg, D.J., Matthews, A.K., McNamara, P.J. & Cao, D. (2016).	Exposure to electronic nicotine delivery systems (ENDS) visual imagery increases smoking urge and desire.	*Psychology of Addictive Behaviors*, 30(1), 106.	6	43	13.95	4.50
White, J., Li, J., Newcombe, R. & Walton, D. (2015).	Tripling use of electronic cigarettes among New Zealand adolescents between 2012 and 2014.	*Journal of Adolescent Health*, 56(5), 522-528.	5	96	5.21	2.05
Barrington-Trimis, J.L., Berhane, K., Unger, J.B., Cruz, T.B., Urman, R., Chou, C.P., ... & McConnell, R. (2016).	The e-cigarette social environment, e-cigarette use, and susceptibility to cigarette smoking.	*Journal of Adolescent Health*, 59(1), 75-80.	4	98	4.08	3.00
Trtchounian, A., Williams, M. & Talbot, P. (2010).	Conventional and electronic cigarettes (e-cigarettes) have different smoking characteristics.	*Nicotine & Tobacco Research*, 12(9), 905-912.	4	176	2.27	1.00
Vena, A., Howe, M., Cao, D. & King, A. (2019).	The role of E-liquid vegetable glycerin and exhaled aerosol on cue reactivity to tank-based electronic nicotine delivery systems (ENDS).	*Psychopharmacology*, 236, 2083-2092.	3	13	23.08	16.20

Knowledge Structure

Knowledge Structure is important to deeply understand an academic field as a dynamic and evolving system (Khare, A. & Jain, R. 2022). It refers to the development of a holistic perspective and an attempt to describe intellectual relationships in an evolving system of scientific knowledge. There are three knowledge structures that provide insight into the hidden patterns of a research field, namely conceptual structure, intellectual structure, and social structure (Chen, W., *et al*., 2024; Khare, A. & Jain, R. 2022).

Mapping the Conceptual Structure

Mapping the Conceptual Structure identifies the main themes, subthemes, and area patterns which are done by identifying words that frequently appear together in the dataset. This allows to identify the concepts behind the words that are closely related (Marchiori, DM, *et al*., 2021). Word TreeMap of Authors' keywords, Author keywords co-occurrence, and thematic map are used in this study to map the Conceptual Structure.

Figure 3 shows the Word TreeMap of authors' keywords. Word TreeMap is the key to investigating hot themes and their developments in this field of study (Zhang, Q., *et al*., 2022). It represents the summary of hot themes or the dynamic trends of dominant themes of the author. Based on Figure 3, the most dominant keywords for research on the theme of e-cigarette smoking behavior are smoking and e-cigarettes. This dominance can be seen in the large square area of the two keywords. More specific keywords associated with e-smoking cigarettes are dominated by electronic cigarettes, smoking cessation, and tobacco. Vaping, adolescents, and nicotine are also widely used keywords.
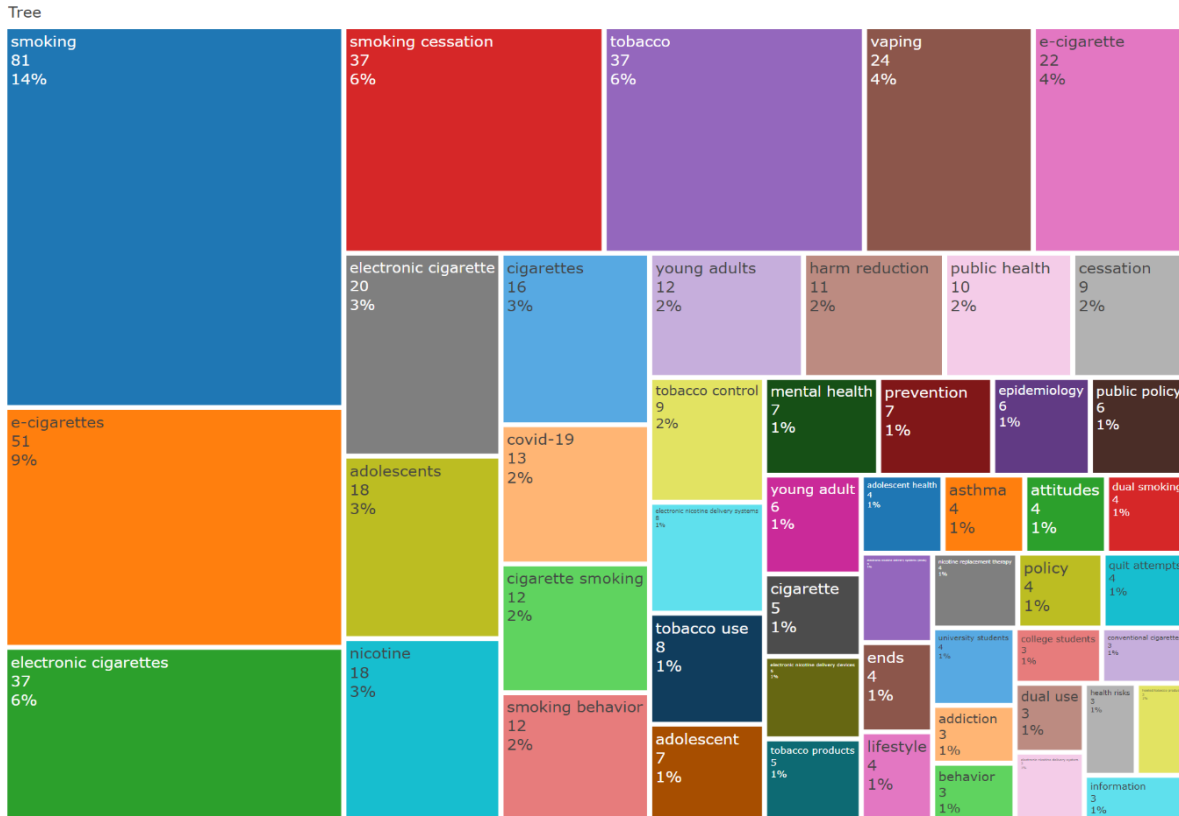
Figure 3: Word tree map of high-frequency keywords

Figure 4 shows the Author keywords co-occurrence network. From the figure, it can be seen that the research theme on e-cigarette smoking behavior is divided into nine main clusters. The first cluster marked with red nodes is the largest cluster consisting of 26 keywords that focus on smoking behavior including aspects such as e-cigarettes, electronic cigarettes, tobacco, vaping, adolescents, young adults, public health, attitudes, lifestyle, college students, and others. The second cluster marked with blue represents research related to external factors that influence e-cigarette smoking behavior, namely public policy and electronic nicotine delivery systems. The third cluster represented by green nodes is related to smoking cessation, harm reduction, and others. The fourth cluster represented by purple nodes is related to epidemiology and tobacco products. The fifth to ninth clusters represent smoking behavior, tobacco use, adolescent health, asthma, and university students, respectively.
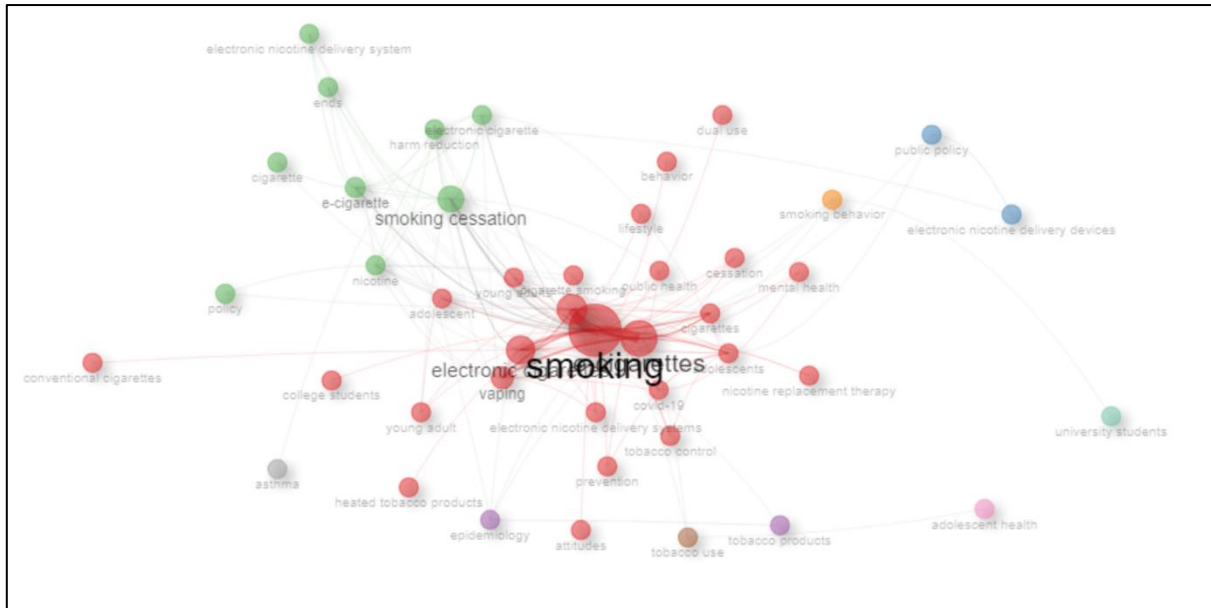
Figure 4: Co-occurrence Network

Figure 5 shows a thematic map representing the research themes. Bubbles on the map are named using keywords that have the highest frequency of occurrence. The size of the bubble reflects the number of occurrences of the word while the position of the bubble reflects the classification of the theme interpreted based on the degree of density and centrality (basic, motor, niche, and declining or emerging themes). Basic themes are highly relevant but underdeveloped research topics in a field (Khare and Jain, 2022). As shown in Figure 5, the most common keywords in the field of e-cigarette smoking behavior research are smoking, e-cigarettes, and electronic cigarettes which are indicated by orange bubbles. Motor themes are well-developed research topics and are important for organizing research topics (Khare, A. & Jain, R. 2022). The themes "nicotine replacement theory" and "electronic nicotine delivery system" are Motor themes in this field. Furthermore, Niche themes are themes that are highly relevant but underdeveloped in a field (Khare, A. & Jain, R. 2022), such as "dual smoking", "behavior" and "systematic review". While Emerging or declining themes are research topics that are likely to have just emerged or are starting to decline and are rarely developed (Khare, A. & Jain, R. 2022) such as "addiction" and "electronic nicotine delicery devices".
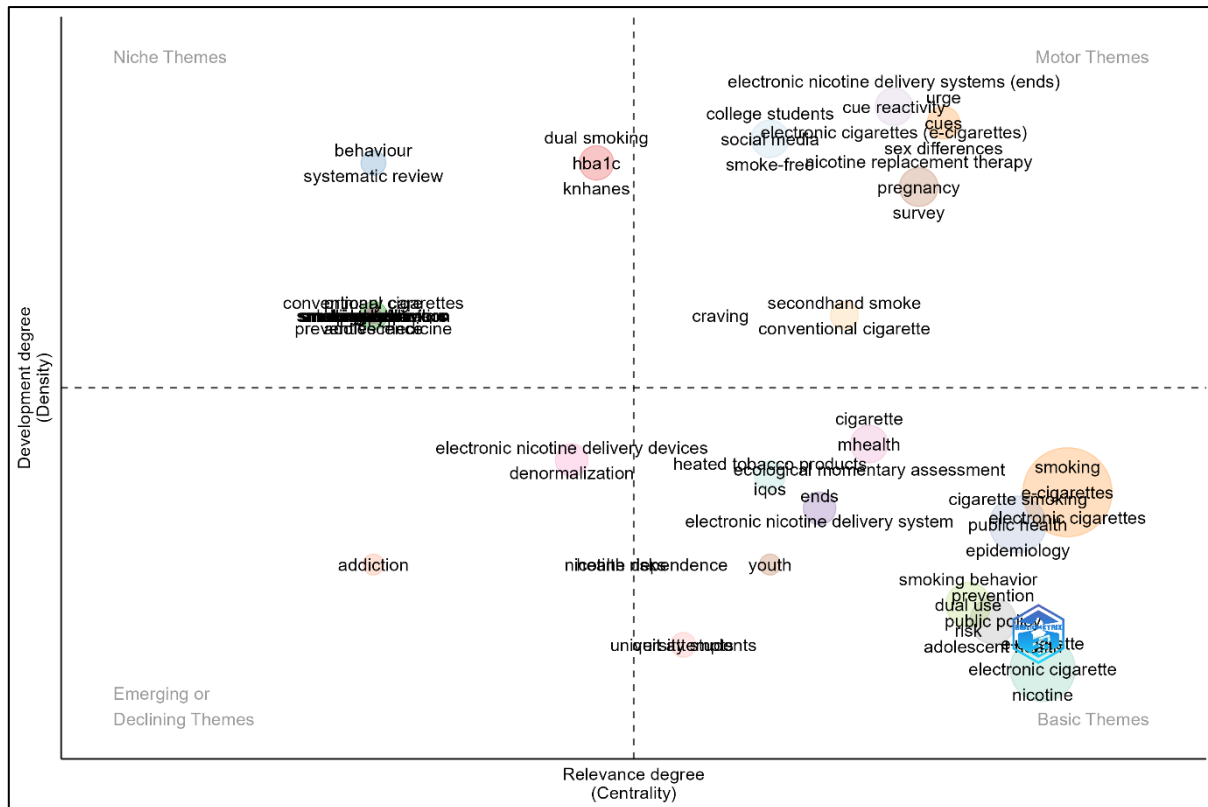
Figure 5: Thematic Map

Mapping the Intellectual Structure

Intellectual structure examines authors, documents, or sources that have a major influence in an academic field and play a role in the dissemination of knowledge (Khare, A. & Jain, R. 2022). The main themes, subthemes, and patterns in the field are identified based on their conceptual structure (Khare, A. & Jain, R. 2022). Intellectual structure consists of two aspects, namely the knowledge base and the research field (Khare, A. & Jain, R. 2022). Co-citation analysis is carried out to reveal the knowledge base, while for the research field, bibliographic coupling analysis is carried out.

The first Intellectual Structure Mapping in this study is Co-citation analysis. Co-citation analysis measures the similarity of authors, documents, and sources that are cited together (Khare, A. & Jain, R. 2022). The results of the Co-citation analysis are shown in Figure 6. The analysis revealed two clusters of basic articles. Goniewicz *et al.*, is the author whose article is the foundation in this field. This article discusses the health impacts of e-cigarette use on adolescents. While in cluster 2, Etter JF is the author whose article is the foundation. This article tests the theory of the initiation gateway of e-cigarettes which is thought to be the gateway to smoking habits in non-smokers. This article concludes that smoking has had a very large political influence. Policies based on this theory will not have the desired effect if the relationship between vaping and smoking is explained by general responsibility.
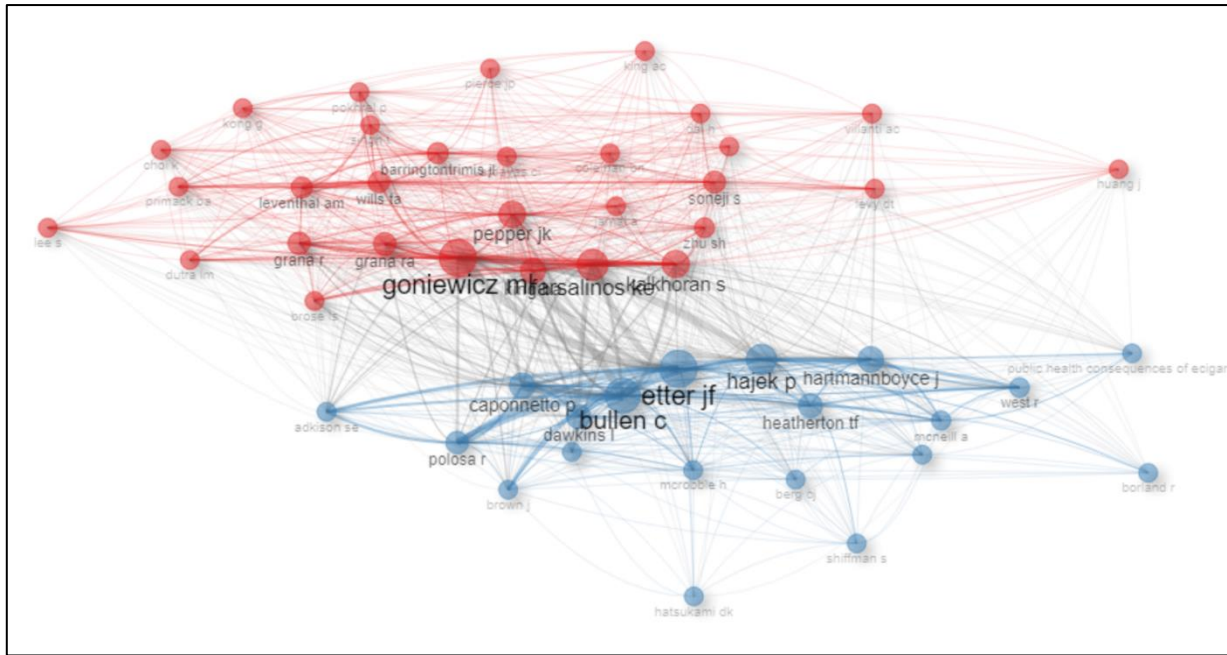
Figure 6: Co-citation network of documents.

Mapping the Social Structure

Figure 7 maps the interactions and collaborations among authors in the dataset. The co-authorship network also maps the interactions and collaborations of author affiliations and their impact on the development of the e-cigarette smoking behavior research field. There are nine main clusters of author collaborations that have made significant contributions to the research on e-cigarette smoking behavior. This is indicated by different colored node groups. The largest cluster is the cluster with red nodes, namely Goniewicz M. To date, Goniewicz M has produced four articles on e-cigarette smoking behavior.

Goniewicz M is an academic at the Department of General and Analytical Chemistry, School of Pharmacy and Laboratory Medicine, Medical University of Silesia, Sosnowiec, Poland and the Tobacco Dependence Research Unit, Wolfson Institute of Preventive Medicine, Queen Mary University of London, United Kingdom. His research focuses on cigarettes, especially electronic cigarettes. The next largest cluster author collaboration is Vena A, Associate Project Leader-Scientist at Emmes, NIDA Clinical Trials Network, The University of Texas at Austin, who has produced 3 articles to date.
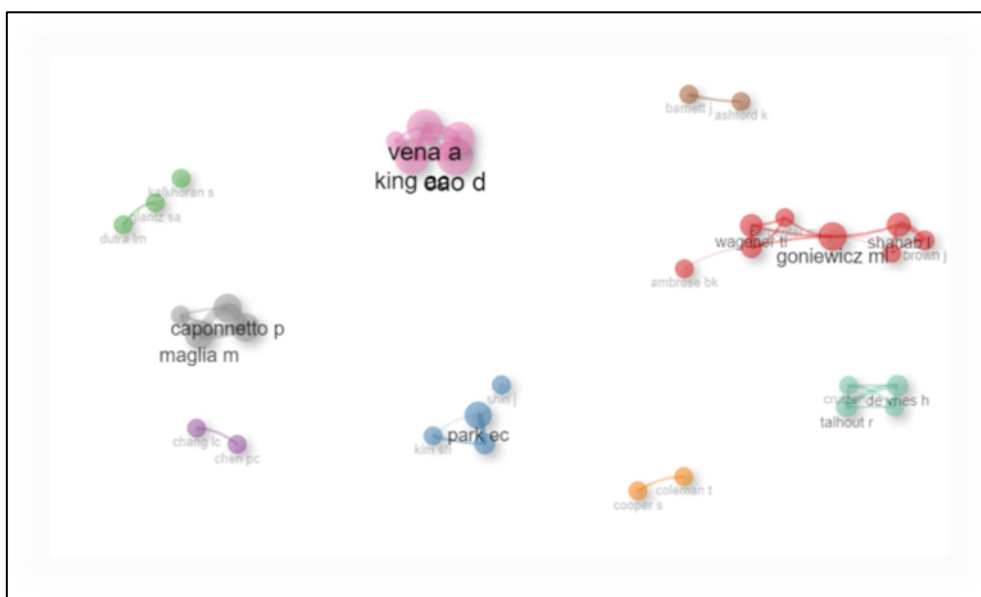

Figure 7: The co-authorship network among authors

Figure 8 shows the countries' collaboration map based on author affiliation. Countries' collaboration map is used to assess the intensity of a country's international cooperation. The line in the figure shows the level of collaboration, the thicker the line indicates the more intense the collaboration between the two countries. Meanwhile, the color of each country is different representing the number of articles produced, where a darker color indicates the number of articles produced in the related country is greater. In the field of e-cigarette smoking behavior research, the USA is the country with the largest contribution developed in dark blue. The USA is also the country with the most collaboration, namely with 21 countries with a total of 30 collaborative publications, followed by the UK which has collaboration with 17 countries and produced 27 articles, and Malaysia with 12 countries producing 12 articles. Meanwhile, the main collaboration in the field of e-cigarette smoking behavior research occurs between the USA and the UK (7 articles), the UK with Germany and Poland (3 articles), and the UK with Australia (3 articles).
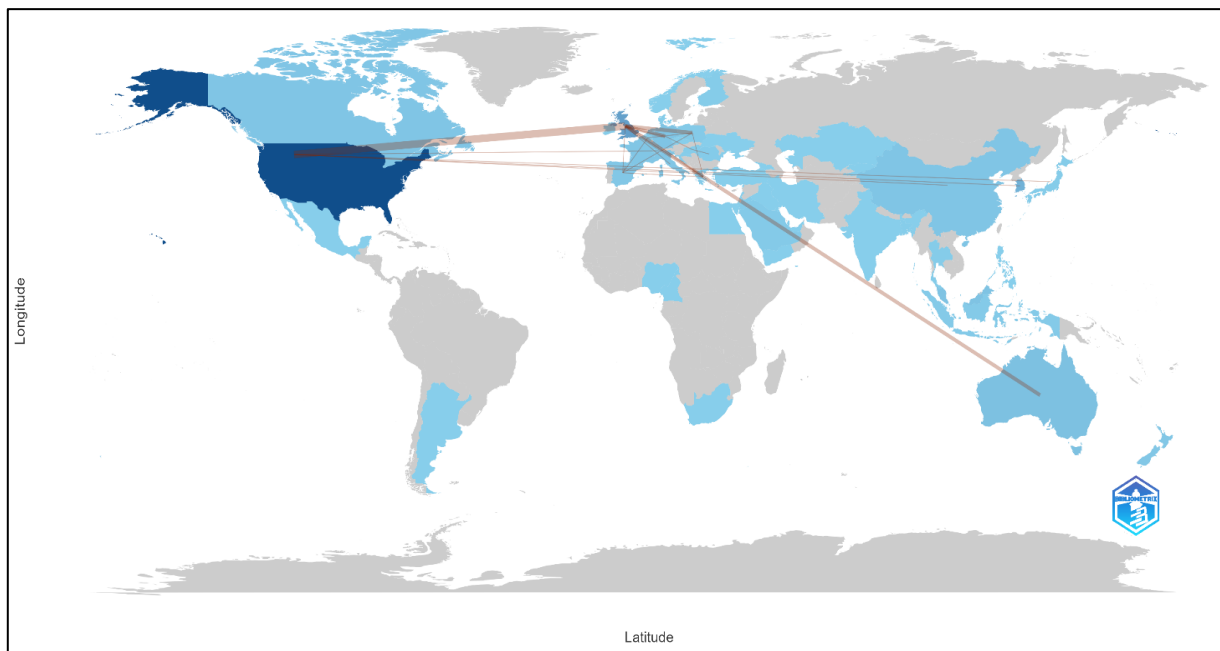

Figure 8. Countries' Collaboration World Map

Future Research Directions

Based on the findings of this study, there are three future studies on e-cigarette smoking behavior. First, the long-term effects of e-cigarette use. Longitudinal studies are needed to understand the long-term health impacts of e-cigarettes and analyze the relationship between e-cigarette use and the risk of certain diseases such as lung disorders, cardiovascular diseases, or cancer. Second, Motivation and behavioral patterns. Research on the motivations of individuals who use e-cigarettes, such as stress reduction, smoking reduction, or social trends and studies of differences in usage patterns based on demographic factors such as age, gender, and culture. This study is needed to see the social and psychological impacts of e-cigarette use including relationships with anxiety, depression, or addiction. Third, the influence of e-cigarettes on social relationships of users, especially among adolescents and young adults. This study can be aimed at the role of the e-cigarette user community in forming new social norms related to smoking habits and the development of community-based interventions to support cessation of e-cigarette use.

CONCLUSIONS AND IMPLICATIONS

This study presents a bibliometric analysis of e-cigarette smoking behavior studies that includes an analysis of publication trends, influential authors, leading journals, and most influential articles. This study specifically also explains the structure of science consisting of conceptual structure, intellectual structure, and social structure of e-cigarette smoking behavior research. The analysis was conducted on 290 Scopus-indexed journal articles published from 2007 to 2024.

The findings of this study indicate that the publication of articles related to e-cigarette

*Corresponding Author: Winda Widyanty

smoking behavior generally shows an increase. Although there was no increase in the early period since the first article was found, over the past decade the number of article publications has increased significantly with an annual growth rate of 21.65%. One thousand three hundred and sixty-six authors contributed to the writing of e-cigarette smoking behavior articles with Cao D and Park EC being the most productive authors in this field. While the most preferred authors with the highest total citations are Polosa R, Maglia M, and Caponnetto P.Tobacco control, Nicotine and Tobacco etcBMC PUBLIC HEALTHbecome a journal that is preferred by many authors to publish their articles related to e-cigarette smoking behavior.

The conceptual structure mapping based on Word TreeMap of authors' keywords shows the most dominant keywords for research on the theme of e-cigarette smoking behavior,electronic nicotine delivery system and smoking cessation. Intellectual Structure Mapping based on Co-citation analysis reveals that Goniewicz, *et al.,* and Etter JF are the authors whose articles are the basis for research in the field of e-cigarette smoking behavior. Meanwhile, based on Countries' collaboration map, in the field of e-cigarette smoking behavior research reveals that the USA is the country with the largest contribution and the most collaboration, namely with 21 countries with a total of 30 collaborative publications. The main collaboration in this field of research occurs between the USA and the UK which produces 7 articles.

Furthermore, this study has several implications. First, this analysis fills the gap in the existing literature by offering an up-to-date bibliometric analysis of journal articles on the topic. Second, this study informs future research opportunities. Researchers can focus on areas that have not been fully explored. Third, the findings of this study, such as the leading journals can be used to assist researchers in searching for literature on related topics and targeting journals to publish their work. Impactful authors provide information related to authors that can be used as references for researchers who want to research on the topic of e-cigarette smoking behavior. Fourth, the findings of this study highlight many factors that influence e-cigarette smoking behavior that can be used as guidelines in developing health intervention strategies.

LIMITATION

This study has several limitations, including, first, the discussion is limited to articles written in English. Second, this study only uses one database, namely Scopus. Thus, a more comprehensive bibliometric study is needed. This is because there are still many articles about e-cigarette smoking behavior that may have an impact but are published in other indexed journals so that they can produce significant changes in the rankings produced in this study.

REFERENCE

1. Bennett, B. L., Deiner, M. & Pokhrel, P. "College anti-smoking policies and student smoking behavior: A review of the literature." *Tobacco Induced Diseases*, 15 (2017): 1-11.
2. Briganti, M., Delnevo, C. D., Brown, L., Hastings, S. E. & Steinberg, M. B. "Bibliometric analysis of electronic cigarette publications: 2003–2018." *International Journal of Environmental Research and Public Health*, 16.3 (2019): 320.
3. Cantrell, J., Huang, J., Greenberg, M. S., Xiao, H., Hair, E. C. & Vallone, D. "Impact of e-cigarette and cigarette prices on youth and young adult e-cigarette and cigarette behavior: Evidence from a national longitudinal cohort." *Tobacco Control*, 29.4 (2020): 374-380.
4. Chand, B. R. & Hosseinzadeh, H. "Association between e-cigarette use and asthma: A systematic review and meta-analysis." *Journal of Asthma*, 59.9 (2022): 1722-1731.
5. Chen, W., Chen, G., Qi, S. & Han, J. "Trends of electronic cigarette use among adolescents: A bibliometric analysis." *Tobacco Induced Diseases*, 22 (2024).
6. Coleman, B. N., Apelberg, B. J., Ambrose, B. K., Green, K. M., Choiniere, C. J., Bunnell, R. & King, B. A. "Association between electronic cigarette use and openness to cigarette smoking among US young adults." *Nicotine & Tobacco Research*, 17.2 (2015): 212-218.
7. Creamer, M. R., Dutra, L. M., Sharapova, S. R., Gentzke, A. S., Delucchi, K. L., Smith, R. A. & Glantz, S. A. "Effects of e-cigarette use on cigarette smoking among US youth, 2004–2018." *Preventive Medicine*, 142 (2021): 106316.
8. Donthu, N., Kumar, S., Pandey, N. & Mishra, A. "Mapping the electronic word-of-mouth (eWOM) research: A systematic review and bibliometric analysis." *Journal of Business Research*, 135 (2021): 758-773.

9. Gordon, T., Karey, E., Rebuli, M. E., Escobar, Y. N. H., Jaspers, I. & Chen, L. C. "E-cigarette toxicology." *Annual Review of Pharmacology and Toxicology*, 62.1 (2022): 301-322.

10. Hammond, D., Reid, J. L., Cole, A. G. & Leatherdale, S. T. "Electronic cigarette use and smoking initiation among youth: A longitudinal cohort study." *CMAJ*, 189.43 (2017): E1328-E1336.

11. Hirsch, J. E. & Buela-Casal, G. "The meaning of the h-index." *International Journal of Clinical and Health Psychology*, 14.2 (2014): 161-164.

12. Khare, A. & Jain, R. "Mapping the conceptual and intellectual structure of the consumer vulnerability field: A bibliometric analysis." *Journal of Business Research*, 150 (2022): 567-584.

13. Kwon, E., Seo, D. C., Lin, H. C. & Chen, Z. "Predictors of youth e-cigarette use susceptibility in a US nationally representative sample." *Addictive Behaviors*, 82 (2018): 79-85.

14. Maloney, E. K. & Cappella, J. N. "Does vaping in e-cigarette advertisements affect tobacco smoking urges, intentions, and perceptions in daily, intermittent, and former smokers?" *Health Communication*, 31.1 (2016): 129-138.

15. Marchiori, D. M., Popadiuk, S., Mainardes, E. W. & Rodrigues, R. G. "Innovativeness: A bibliometric vision of the conceptual and intellectual structures and the past and future research directions." *Scientometrics*, 126 (2021): 55-92.

16. Marques, P., Piqueras, L. & Sanz, M. J. "An updated overview of e-cigarette impact on human health." *Respiratory Research*, 22.1 (2021): 151.

17. Martins, B. N. F. L., Normando, A. G. C., Rodrigues-Fernandes, C. I., Wagner, V. P., Kowalski, L. P., Marques, S. S. & Santos-Silva, A. R. "Global frequency and epidemiological profile of electronic cigarette users: A systematic review." *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 134.5 (2022): 548-561.

18. Olson, C. K., Sherwood, N., Berkane, M., Gilligan, K. & McKinney Jr, W. J. "Perceptions, intentions, and actual use of a consumer nicotine gum." *Harm Reduction Journal*, 20.1 (2023): 132.

19. Regan, A. K., Promoff, G., Dube, S. R. & Arrazola, R. "Electronic nicotine delivery systems: Adult use and awareness of the 'e-cigarette' in the USA." *Tobacco Control*, 22.1 (2013): 19-23.

20. Rodríguez-Ruiz, F., Almodóvar, P. & Nguyen, Q. T. "Intellectual structure of international new venture research: A bibliometric analysis and suggestions for a future research agenda." *Multinational Business Review*, 27.4 (2019): 285-316.

21. Smith, S. Y., Curbow, B. & Stillman, F. A. "Harm perception of nicotine products in college freshmen." *Nicotine & Tobacco Research*, 9.9 (2007): 977-982.

22. Stanton, C. A., Pasch, K. E., Pericot-Valverde, I., Cruz-Cano, R., Moran, M. B., Abadi, M. H. & Chen-Sankey, J. "Longitudinal associations between US youth exposure to e-cigarette marketing and e-cigarette use harm perception and behavior change." *Preventive Medicine*, 164 (2022): 107266.

23. Sun, T., Lim, C. C., Stjepanović, D., Leung, J., Connor, J. P., Gartner, C. & Chan, G. C. "Has increased youth e-cigarette use in the USA, between 2014 and 2020, changed conventional smoking behaviors, future intentions to smoke and perceived smoking harms?" *Addictive Behaviors*, 123 (2021): 107073.

24. Wang, J., Li, X., Wang, P., Liu, Q., Deng, Z. & Wang, J. "Research trends of the unified theory of acceptance and use of technology theory: A bibliometric analysis." *Sustainability*, 14.1 (2021): 10.

25. Wang, R. J., Bhadriraju, S. & Glantz, S. A. "E-cigarette use and adult cigarette smoking cessation: A meta-analysis." *American Journal of Public Health*, 111.2 (2021): 230-246.

26. Wills, T. A., Knight, R., Sargent, J. D., Gibbons, F. X., Pagano, I. & Williams, R. J. "Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii." *Tobacco Control*, 26.1 (2017): 34-39.

27. Xu, Y., Gu, Z., Zhang, Y., He, M., Gerber, B. S., Sadasivam, R. S. & Wang, Z. "Global trends in smoking cessation research from 2002 to 2021: A bibliometric and visual analysis." *Preventive Medicine Reports*, 30 (2022): 101991.

28. Zhang, Q., Fan, X., Yue, Y. & Zheng, R. "Electronic cigarettes: Emerging trends and research hotspots." *Tobacco Induced Diseases*, 18 (2020).

Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:

Widyanty, W. and Ayubi, D. "E-Cigarette Smoking Behavior: A Review and Bibliometric Analysis." *Sarcouncil Journal of Internal Medicine and Public Health* 3.6 (2024): pp 12-27.