Research Patterns in the Usage of E-Cigarette and their Health Risks: Bibliometric and Scientometric Review from 2009 - 2023

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Abstract

In the past decade, electronic cigarettes emerged as a possible harm-reduction instrument in nicotine consumption, sparking extensive research interest. While comparisons between e-cigarettes and traditional tobacco products have been conducted, the long-term health consequences of e-cigarette utilization remain unclear. This research conducted a study analyzing publications to investigate patterns of research in the domain of e-cigarettes and e-liquids usage and its health risk by utilizing the Scopus database, Biblioshiny, and VOS viewer to identify the trends in this subject and providing insight into the current state of research in this area. Three types of analysis—performance analysis, ranking analysis, and scientific mapping—were conducted using a dataset comprising 212 research papers obtained from the Scopus database. This analysis includes a visual representation of document types, author keywords, international collaborations, and yearly scientific output. This research also identified the most significant authors and affiliations, as well as scientific production by country. Word clouds and network visualizations show the most relevant words and their relationships in research. Furthermore, this research also provides a general overview of the potential harm-reduction tool as well as the future impact of e-cigarettes on health risks.

Keywords: bibliometric, cancer, health, e-cigarette, VOS viewer.

Tobacco harm reduction methods have made significant progress in the last decade. Products such as e-cigarettes and e-liquids have become the focus of global research and discussion. Scientific publications published from 2009 to 2023 have documented the dynamics of adoption and health impacts of this approach in various countries. Research [1] provides an overview of the occurrence of awareness and usage of electronic cigarettes in several nations, that can

be utilized as basic data for monitoring, evaluation, and intervention. Replacing combustible tobacco products with non-combustible tobacco products is considered essential for tobacco harm reduction because it produces lower toxins and risks [2].

A comparison of health risks between tobacco harm reduction products, including e-cigarettes and e-liquids with conventional cigarettes is essential in several studies. Several risks have been identified regarding the use of this product. Although considered a safer alternative, scientific evidence, as described [3], shows that these products still contain dangerous substances and have different health impacts that need to be seriously considered [4]. The utilization of electronic cigarettes as a substitute for traditional tobacco products and their health impacts are of concern in global health. E-cigarettes are claimed to be able to help cigarette addicts to stop smoking [5]. However, accompanying the rise in e-cigarette use, concerns have arisen about the health risks linked to e-cigarette use [6] [7].

Substantial evidence is demonstrated by [8] regarding the link between smoking and lung cancer and oral cavity cancer. The lack of regulation leads to a wide variety of electronic cigarette devices and varying nicotine concentrations in circulation. This makes it difficult to identify what users are inhaling, complicating early diagnosis, especially in cancer cases [9]. In this study [10], under the same heating power, e-cigarette shows lower nicotine emissions than conventional cigarettes. Another study found that short-term and prolonged e-cigarette use might be linked to acute cardiopulmonary or respiratory risks [11]. However, currently, a research [12] poses that aerosol from e-cigarettes triggers stress and mitochondrial toxicity, as well as DNA damage and fragmentation linked to cancer advancement and cell migration.

Electronic cigarettes are classified as Electronic Nicotine Delivery Systems (ENDS). The potential for ENDS against cancer is caused by four groups of compounds, including tobacco-specific nitrosamines, metals, volatile organic compounds, and polycyclic aromatic hydrocarbons (PAH) [13]. It is further stated that ENDS emits fewer carcinogenic substances compared to combustible tobacco or combustible tobacco due to the absence of combustion, but they still have health effects. According to [14], there exists limited evidence that e-cigarettes are dangerous and have the potential to cause head and neck cancers.

The use of e-cigarettes has become widespread throughout the world, and reducing exposure to harmful chemical compounds produced by e-cigarettes is a major concern [15]. Since they were first introduced commercially in 2003, electronic cigarette consumption has continued to increase in various segments of society [16]. The utilization of electronic cigarettes remains a contentious subject of discourse even now due to differences in views regarding whether ENDS have benefits as a tool to help heavy smokers reduce the negative impacts of conventional cigarettes, or conversely, whether ENDS carries the risk of being a "gateway" to worse smoking habits [17].

Previous research provides valuable insight into harm reduction use of tobacco, including electronic cigarettes and their liquid formulations. Research [18] in Nicotine & Tobacco Research presents an initial analysis regarding the efficacy of electronic cigarettes in aiding smokers to quit smoking. In other studies, a meta-analysis was conducted [19] regarding the health risks of cancer and smoking. Another meta-analysis study was conducted [20] observationally to assess the connection between reducing tobacco use and various health risks. These references provide a framework for further understanding the health risks posed by smoking.

The swift advancement of science and technology resulted in significant growth within the academic literature, making it increasingly difficult to organize and examine extensive data. Bibliometrics examines the body of literature, employing quantitative analysis, analysis of

network, and graph theory to explore the numerical relationships, distribution structures, and evolution of patterns within the literature collection. It investigates the composition of scientific literature, utilizing quantitative metrics to illustrate its characteristics and patterns, exposing the internal linkages of resources. It allows us to delve into the evolving investigative subject on e-cigarettes while illuminating the emerging areas.

Bibliometric tools has been extensively used for analysis in many research area, for instance [21] to analyze the bibliometric data of The Indian Journal of Palliative Care (IJPC) publications, exploring focus shift in covid-19 literature. Others studies also using bibliometric tools such as consumer vulnerability field [22], education science [23], in maritime field [24] and many more. However, the studies and literature found in order to map and identify the trends of the e-cigarette usage and their health risks are still limited. The newest bibliometric analysis has been carried out in several previous studies on e-cigarettes, such as [25] [26] [27]. All these studies present the usage of e-cigarettes concerning health risks and map it to identify a global view and trends in e-cigarette research worldwide. However, much of the previous research lacks deeper discussion about the potential harm or illness caused by inhaling e-cigarettes. Therefore, this research aims not only to investigate the directions and trends created by electronic cigarettes by utilizing bibliometrics to scrutinize research domains, publishing nations and institutions, prolific authors, and emerging trends in e-cigarettes over recent years, but also to further investigate and review the potential risks associated with their use. This research is necessary to gain a better understanding of these impacts.

The methodology employed in this research is a scientometric grounded in bibliometric analysis of the risks linked with product usage, including e-cigarettes and e-liquids. The current status of this research emphasizes the need for bibliometric analysis and scientometric to measure the extent of the impact of research regarding the risks of using e-cigarettes as a method of reducing tobacco risks on health. In the context of health risks, bibliometric analysis will help in describing developments in the literature, and formulating future research directions. With the rapid development in this field, bibliometric analysis has become a very relevant and urgent approach to understanding the health impacts of tobacco harm reduction, especially e-cigarettes. In this field, the primary study areas have been the prevalence, awareness, motivations behind e-cigarette use; the utilization of e-cigarettes for tobacco harm reduction; the extent of population exposure; and the relationship between e-cigarettes and tobacco/nicotine use. Scholars have shown an increasing interest in study on e-cigarette research, which has been one of the hot topics. The trends have spanned a wide range of issues. These patterns have changed over the years.

Methodology

Bibliometric methods are employed to identify and analyze scientific literature on the utilization of electronic cigarettes and the health risks they pose published from 2009 to 2023. The first stage of this work is formulating research queries obtained from the gap analysis that has been carried out previously. The question asked was, 'What research results have been published regarding the risks of using electronic cigarettes on health risks, especially cancer?'

The second stage is to identify an appropriate search database. The Scopus platform is considered to have a relevant indexing database. Scopus is the largest database in the world launched by Elsevier [19,20] and displays research papers, including journals and proceedings, and has been utilized by previous researchers [21,22]. The advantages of this database include being able to produce more citations [28] and having wider coverage in several fields [29]. The initial search was carried out with the keywords 'health, risk, cancer, e-

cigarette'. Search results show data of 212 documents. The criteria of the paper type set in the search are article, conference paper, and book chapter in the English language. All review papers, notes, and editorials are excluded.

The bibliometric analysis was performed for selected articles, including title, author, journal, year of publication, and keywords. This analysis was chosen to identify publication trends, researcher collaboration networks, keyword frequencies, and citation patterns. The data that has been collected is visualized in the form of graphs and diagrams to illustrate relevant trends and patterns. A network diagram of researcher collaboration and keywords will help in understanding the relationship between contributors and research focus. Content analysis was conducted on the most commonly appearing keywords to gain deeper insight into the topics most discussed in the literature. The results of the bibliometric analysis are interpreted to gain an understanding of publication trends, researcher contributions, and research focus related to the risks of tobacco harm reduction. With this methodology, a comprehensive picture of the development of literature related to the risks of using tobacco harm-reduction products from a health perspective can be described systematically, and further research directions can be identified.

Results and discussion

This inquiry was formulated using various keywords, including "health*", "risk*", "cancer," and "e-cigarette". This query seeks articles that include these keywords in the title, abstract or keywords. Articles. Consequently, this query yields a compilation of pertinent articles published in scientific journals, conferences, or other publications archived in the Scopus database. This search strategy can find relevant and focused papers, which are further screened by directly checking the abstract. Although there are limitations it does not include databases other than Scopus which need to be considered as data for analysis. According to the search, 212 articles were retrieved. Table 1 shows the search results using Boolean operators in the Scopus database, 2009 – 2023.

The obtained metadata is then analyzed using Biblioshiny and VOSViewer. Biblioshiny is a web-based tool designed to simplify bibliometric analysis, serving as a user-friendly extension of the R package Bibliometrics. Users can effortlessly import and transform data into a set of data frames, enabling bibliometric analysis and visualization through an interactive web interface [30].

Table 1. The identification process of the database.

Keywords	Sources	Results
health, risk, cancer, e-cigarette	Scopus	212

Meanwhile, VOSviewer is employed to create visual representations utilizing co-occurrence matrices, citations, co-citations, and bibliographic coupling networks, or to construct keyword maps derived from co-occurrence networks. VOSviewer is particularly beneficial when dealing with maps that include a relatively substantial quantity of items [31]. The main information is shown in Fig 1.

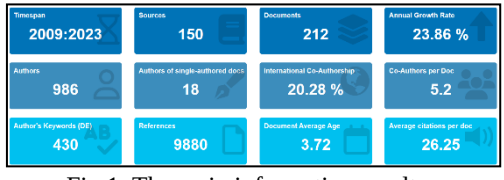


Fig 1. The main information results.

In this research, we encountered two main limitations regarding data sources: First, the study period ranges from 2009 to 2023; second, the data source utilized consists of publications from the Scopus database. The analysis provides an overview of the field's development, focusing on various aspects including the research timeframe, data sources, number of documents,

authors, single-authored documents, international collaboration among authors, author's keywords, references, and the average age of the documents.

The number of documents analyzed provides an extent idea to which this research's reach. Figure 1 depicts the analysis of data analyzed from 2009 to 2023, comprising 150 references and 212 publications with an annual growth in publications of 23.86% and involving 986 authors. It is known that the extent of international collaboration in research is 20.28%, which indicates that around 20.28% of all research partnerships involve two or more researchers from different countries. This indicates an international aspect to e-cigarette research, where researchers collaborate across national borders to conduct joint research projects or contribute to scientific endeavors involving cross-country collaboration. The average age of the documents found was 3.72 years, providing deep insight into the characteristics and relevance of this research in the time context.

Type of Documents

The document types of analysis is among the functionalities offered by Scopus. Following a search query, users can assess the search outcomes using the "Analyze search results" tool. This functionality offers a graphical breakdown of search outcomes categorized into seven sections, including document type. The ensuing visualizations depict the results based on documents by type.

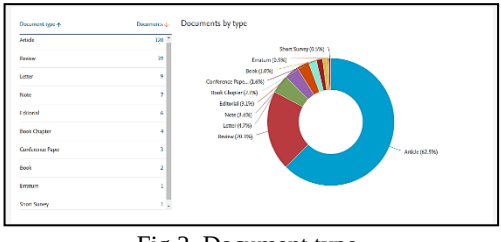


Fig 2. Document type

Fig 2 provides comprehensive information about the types of documents referenced in this research. Among the 120 identified documents, articles are predominant in number, indicating the research focus on scientific literature and research findings. The significant number of reviews (39 documents) suggest a focus on comprehending and synthesizing existing literature reviews. The presence of documents categorized as "letter," "note," and "editorial" suggests diversity in the types of literary contributions utilized. Conversely, contributions classified as "book chapter," "conference paper," and "book" indicate the incorporation of more specialized sources, such as chapters in books, conference papers, and entire books. The presence of a small number of "Erratum" and "Short Survey" documents provides further insight into the author's perceptive of previous methods or research, as well as the emphasis on short surveys.

Yearly Scientific Output

Annual scientific production in bibliometrics involves statistically analyzing the quantity of scientific publications generated by individuals, research groups, institutions, or journals within a given year. This analysis seeks to gauge productivity and efficacy in the scientific realm and can be utilized to chart trends and tendencies of scientific advancement within particular fields. [21]. Fig 3 provides a visualization of the Annual Scientific Production produced in the period 2009 – 2023.

Figure 3 shows information about institutions or affiliations as well as the number of articles related to the research. Annual scientific output generated during the timeframe 2009 to 2023 reflects significant developments in research activities. If these data include the number of scientific publications or research works produced annually, the rise in production since 2013 indicates a growing level of research activity. This indicates a growth in research capacity and wider access to research resources. Additionally, this increase may also signify a

trend and research emphasis on the connection between electronic cigarettes and health risks.

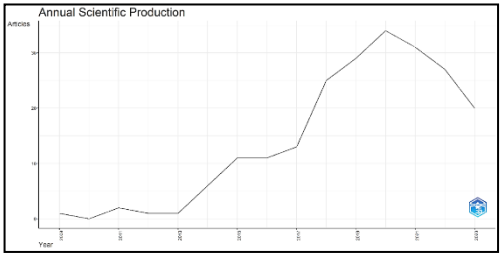


Fig 3. Scientific output published annually from 2009 to 2023

Primary author

In Bibliometrics, the most relevant author is the author with the greatest number of publications or citations within a specific dataset [30]. The visualization of the most prominent author produced in the period 2009 to 2023 is shown in Fig 4.

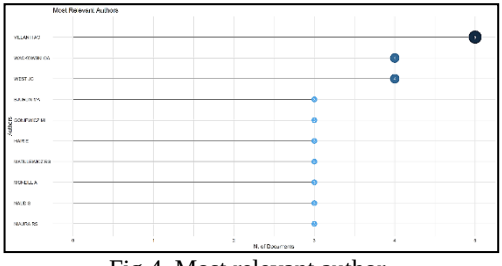


Fig 4. Most relevant author

In Fig 4, Villanti AC the most productive authors, having authored five articles, indicating a significant contribution to e cigarette research. Additionally, Wackowski OA and West JC, with four articles each, have also made substantial contributions to this research. Furthermore, many authors such as Bjurlin MA, Goniewicz ML, Hair E, Matulewicz RS, Mcneill A, Naud S, Niaura RS, Ostroff JS, Patil S, Pearson JL, Polosa R, Popova L, Raj AT, Rath JM, Dan Toll The Bas, each with three articles, also demonstrate important involvement in the research. Figure 4 highlights authors who have made significant contributions and had a strong impact on the field of e-cigarette research, guiding its direction and development.

Most Pertinent Affiliations

In bibliometrics, the affiliation that matters the most is the institution that seems most frequently when conducting bibliometric analysis. This can provide insights into the involvement of a certain organization in a given field of study[32].

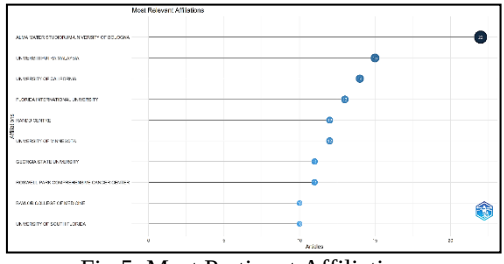


Fig 5. Most Pertinent Affiliations

Fig 5 shows the contribution of various institutions in e-cigarette research. Alma Mater Studiorum-University of Bologna emerged as the most productive organization, with 22 documents demonstrating its central position in the study. Universiti Putra Malaysia, University of California, and Florida International University also made notable contributions, each publishing more than 10 articles. Furthermore, institutions such as the Rand Center and the University of Minnesota, Georgia State University and the Roswell Park Comprehensive Cancer Center, as well as Baylor College of Medicine, the University of South Florida, and the University of Vermont have all significantly contributed with 10 or more articles. This shows the diversity and involvement of various institutions in research concerning the health risks posed by e-cigarettes. The data reflects cross-institutional collaboration and diverse resources, offering insight into the extent of the role of various academic institutions.

Nations with High Scientific Production

In bibliometrics, the nation with high scientific production is that quantifies the

quantity of scientific publications a nation produces on a given topic [23]. Moreover, bibliometrics can be utilized to examine international collaboration patterns in scientific research. In this approach, the number of scientific papers written by authors from different nations can be used to gauge how closely nations collaborate in a certain field of study [24]. Table 2 shows a visualization of the scientific output of countries that have produced these publications between 2009 – 2023.

Table 2 Countries scientific production

Region	Frequency	Region	Frequency
USA	536	Austria	6
UK	108	Portugal	6
Italy	86	Switzerland	6
Canada	50	Japan	5
Malaysia	35	Spain	5
Polang	35	Nee Zeland	4
Australia	28	Norwey	3
France	24	Belgium	2
China	17	Iraq	2
Saudi Arabia	15	Mexico	2
Germany	13	Singapore	2
South Africa	12	United Arab Emirate	2
Brazil	11	Colombia	1
India	11	Georgia	1
Jordan	10	Greece	1
South Korea	10	Israel	1
Netherland	8	Jamaica	1
Serbia	8	Slovenia	1
Ireland	7	Sweden	1

Table 2 shows scientific output of authors from various countries, giving a clear overview of each country's contributions to e-cigarette related cancer risk research. The United States (USA) dominates with a significant number of publications, namely 536 authors, which reflects its prominent position in the scientific literature in this area. England (UK) and Italy (Italy) also play significant role, having a high number of publications, with 108 and 86 authors, respectively. Countries such as Canada, Malaysia, and Poland make notable contributions, with 50, 35, and 35 authors, respectively. However, it is important to mention that some certein countries, such as Indonesia, have made lower contributions or even no publications on the research topic being discussed.

Most Relevant Words

In bibliometric analysis, the most relevant word is crucial in identifying the most relevant keywords or concepts [30]. Fig 6 provides a visualization of the most relevant words and word clouds produced between 2009 – 2023.

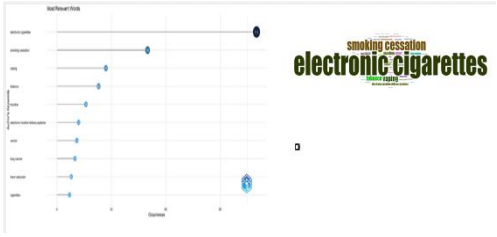


Fig 6. Most relevant words and word cloud

Fig 6 shows the word cloud visualization, where in Bibliometric, a tool for visualizing the frequency of words in bibliographic papers is the word cloud that serves the bibliometric examination using visual representing the most frequently occurring keywords in bibliographic documents. A word cloud can be used to visually represent word frequency interestingly and educationally [30]. The phrase "electronic cigarettes" dominates with 110 occurrences, indicating the importance of these devices in the context of this research. "Smoking cessation" also had a significant occurrence with 50 times, reflecting attention to smoking cessation efforts concerning e-cigarette use. Furthermore, words like "vaping," "tobacco," and "nicotine" were also commonly seen, showing the wide range of topics covered in this study. Words that appear with lower frequency, such as "cancer," "harm reduction," "public health," and others, also provide additional insight into the relevant topics in this study.

Network Visualization

Network visualization displays the connections between keywords within a network. Network visualization in bibliometric analysis can show relationships between concepts that are shown [31]. This data visualization uses author keywords and co-occurrence analysis type as an element of analysis with a minimum of 5 documents to create a network. This visualization covers the period from 2009 to 2023. Fig 7 illustrates the keyword-based network visualization.

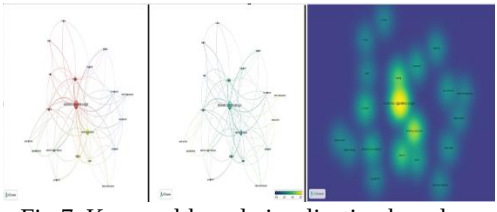


Fig 7. Keyword-based visualization based on keywords, overlay visualization, and density visualization.

Fig 7 shows a network visualization, featuring nodes (circles) representing keywords and edges (networks) indicating relationships between these keywords. A group of nodes connected by edges illustrates the correlation or relationship between keywords. The larger the node, the more clusters are generated [33]. Furthermore, one kind of visualization offered by VOSviewer is overlay visualization. With the use of distinct colors or symbols, users can distinguish between two different types of data displayed in a single graphic thanks to the overlay visualization. This tool aids users in visually comparing and analyzing the connection between two types of data [31]. The overlay visualization depicted in Fig 7 is organized based on the minimum requirement of producing five documents to generate one network.

The VOSViewer application's density visualization function is used to show how prominent or concentrated research groups are. There are two types of it: cluster density and item density. Similar to network and overlay visualizations, item density visualization uses labels to represent things. Conversely, cluster density visualization uses circles of varying sizes to represent items based on the research group's density [31].

Map of Countries Collaborating

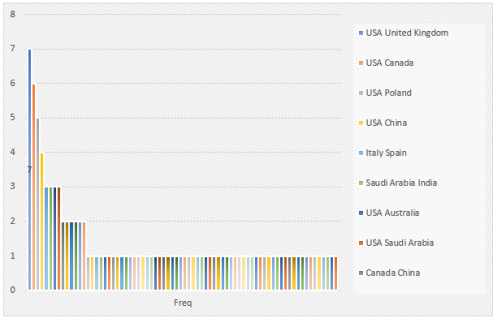
A map of bibliometric national collaborations illustrates the cooperation between countries in scientific papers or publication writing. It shows how frequently different nations collaborate in particular research fields. Understanding international research trends and cross-national cooperation in particular fields of study can be aided by this map [34]. Table 3 shows a visualization derived from the country collaboration map generated from 2009 – 2023.

According to the information in Table 3, inter-country research collaboration plays a key role in global scientific cooperation. In the lead is the United States of America (USA), with 50 collaborations with various countries. The United Kingdom, Canada, Poland and China are also show active involvement in research collaboration, demonstrating a significant level of international cooperation in scientific research. This collaboration facilitates knowledge exchange, enhances scientific discoveries, and broadens research scope. However, the absence of Indonesia in this data suggests the potential for increased participation in international research collaborations.

Table 3. Visualization of the country collaboration map

From	To	Freq	From	To	Freq	From	To	Freq
USA	United Kingdom	7	China	Japan	1	Spain	Slovenia	1
USA	Canada	6	China	Netherlands	1	Spain	Sweden	1

From	To	Freq	From	To	Freq	From	To	Freq
USA	Poland	5	China	Singapore	1	United Kingdom	Australia	1
USA	China	4	Italy	Australia	1	United Kingdom	Brazil	1
Italy	Spain	3	Italy	Netherlands	1	United Kingdom	Canada	1
Saudi Arabia	India	3	Italy	Poland	1	United Kingdom	China	1
USA	Australia	3	Italy	Slovenia	1	United Kingdom	Germany	1
USA	Saudi Arabia	3	Italy	Sweden	1	United Kingdom	Israel	1
Canada	China	2	Italy	United Arab Emirates	1	United Kingdom	Italy	1
USA	India	2	Jordan	United Arab Emirates	1	United Kingdom	Netherlands	1
USA	Italy	2	Korea	Singapore	1	United Kingdom	Poland	1
USA	Japan	2	Malaysia	Australia	1	United Kingdom	United Arab Emirates	1
USA	Korea	2	Malaysia	Japan	1	USA	Colombia	1
USA	Netherlands	2	Mexico	Jamaica	1	USA	Georgia	1
Australia	China	1	Netherlands	Israel	1	USA	Greece	1
Australia	India	1	Netherlands	Slovenia	1	USA	Israel	1
Australia	Israel	1	Netherlands	Spain	1	USA	Jamaica	1
Australia	Korea	1	Netherlands	Sweden	1	USA	Mexico	1
Australia	Netherlands	1	Poland	Netherlands	1	USA	New Zeland	1
Australia	Saudi Arabia	1	Poland	Slovenia	1	USA	Singapore	1
Canada	Australia	1	Poland	Spain	1	USA	Slovenia	1
Canada	Colombia	1	Poland	Sweden	1	USA	Spain	1
Canada	Israel	1	Saudi Arabia	Jordan	1	USA	Sweden	1
Canada	Netherlands	1	Slovenia	Sweden	1	USA	United Arab Emirates	1
China	Israel	1	South Africa	Korea	1			



Thematic Map

A niche theme in bibliometric analysis indicates a particular research subject that needs additional in-depth investigation. The Motor Theme is a highly productive and significant field of study. Research topics that are becoming more and more popular are called Emerging Themes. A declining theme is a topic of study that is becoming less well-known and attention-grabbing. A basic theme is the central notion or concept that underpins a certain subject of study [22]. Thus, it is understood that:

- Top left (Niche): Lots of articles, however, they only have a little effect because they are solitary within a particular theme.
- Top Right (Motor): Lots of articles, lots of power.
- Bottom Left (Emerging or Declining): There aren't many articles; they're either quite new or need more clout. (still in the embryonic stage).
- Bottom Right (Basic): There aren't many articles here, but they have a big impact.

Fig 8 and Table 4 illustrate clusters of keywords in the Niche category, including "anesthesia," "adolescent," "young adults," and "respiratory deposition," showing the relationship of elements concerning specific medical and health topics, one of which pertains to the influence of electronic cigarette use. Although this cluster contains many articles, their impact is constrained in a limited topical scope. Moreover, within the motor group, we identified keywords such as, "e-liquid," "cigarettes," "e-cigarette," and "electronic nicotine delivery devices" all related to e-cigarettes and related products used in e-cigarette practices. The three main keywords, "e-liquid," "cigarettes," and "e-cigarette," are closely linked in the context of electronic smoking. These are the elements involved in the utilization and encounter of electronic smoking. "Electronic nicotine delivery devices" is a broader, overarching term describing devices that deliver nicotine through vapor. The number of articles in this group is large and has a significant impact. Fig 8 represent a visualization derived from Thematic Map generated between 2009 – 2023.

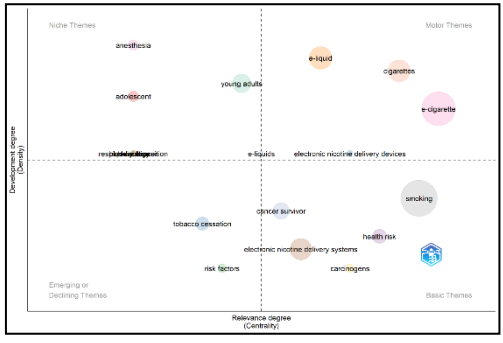


Fig 8. Thematic Map

The emerging or declining category included the terms "tobacco cessation" and "risk factors," which are closely linked in the context of health and efforts to stop tobacco consumption. These keywords indicate the connection between an effort to stop smoking ("tobacco cessation") and factors that can impact the success of such attempts ("risk factors"). Some of these risk factors include nicotine addiction, environmental stress, and psychological factors. This group has a limited number of articles, is in its initial stages of development, or has not yet made a significant impact (still in the early development stage). The final group is basic, consisting of keywords "smoking," "cancer survivor," "health risk," "electronic nicotine delivery systems," and "carcinogens," which are closely related in the context of health research. Analyzing the

connection between these keywords reveals the adverse smoking consequences ("smoking") on health, including the likelihood of developing cancer "Carcinogens" are substances that cause cancer and can be present in traditional cigarettes. Studies on "cancer survivors" focus on individuals who have beaten cancer and might face increased health risks, particularly if they continue to smoke. The application of "electronic nicotine delivery systems" might also pose health risks, and research might aim to comprehend their long-term health effects. Examination of this group highlights the necessity for a more profound understanding of how smoking and e-cigarette use impact cancer risk and health in cancer survivors, along with the role of carcinogens in this process. Despite the articles are limited, the impact is significant.

Table 4. Thematic label cluster map

Cluster_Label	Words
adolescent	adolescent
	risk perception
tobacco cessation	tobacco cessation
	lung cancer screening
risk factors	risk factors
health risk	health risk
	e-cigarette aerosol
e-liquid	e-liquid
	toxicity
	cancer risk
	indoor air quality
	e-cig
	emissions
	guidelines
	margin of exposure
	risk assessment
electronic nicotine	electronic nicotine delivery
delivery systems	systems
	cigarette smoking
	e-cig use
	tobacco products
e-cigarette	e-cigarette
	vaping
	electronic cigarette
	cancer
	lung cancer
	harm reduction
	public health problem
	health
	tobacco control
	alcohol
	cessation
	heated tobacco products
	addiction
	ehealth
	epidemiology
	policy
	social media
	aerosol
	cancer prevention
	health effects
	risk
	smoking reduction
	topic modelling
smoking	smoking
	e-cigarettes
	electronic cigarettes
	tobacco
	nicotine
	tobacco harm reduction
	ends
	head and neck cancer
	mental health
	cardiovascular disease
	covid-19
	harm perception
	health risks
	heat-not-burn
	mortality
	nicotine dependence
	respiratory disease
	waterpipe
	asthma
	dual use
	nicotine replacement therapy
	oral cancer
	pregnant woman
	preoperative
	pulmonary disease
	shisha
	tobacco heating product
young adults	young adults
	adults
	harm perceptions
	reduced nicotine content
	systematic reviews as topic
cigarettes	cigarettes
	risk perceptions
	health information
	smokeless tobacco
	hispanic
	risk communication
	warnings
cancer survivor	cancer survivor
	cigarette
	substance use
anesthesia	anesthesia
	vaping/adverse effects
carcinogens	carcinogens
bladder cancer	bladder cancer
e-liquids	e-liquids
electronic nicotine delivery devices	electronic nicotine delivery devices
prevention	prevention
respiratory deposition	respiratory deposition
toxicology	toxicology

The impact of e-cigarettes on health risk

The relationship between tobacco harm reduction and health risks has been discussed. Electronic cigarettes harbor metallic elements within their composition and carbonyl

compounds that possess cardiotoxic properties and exhibit acute toxicity toward the vascular system [34,35]. The utilization of e-cigarettes impacts the human cardiopulmonary system, demonstrating indications of diminished lung function and heightened blood pressure, heart rate, and arterial rigidity in comparison to individuals who neither smoke nor use vaping devices [35]. E-cigarettes can also induce negative effects in cells or animal models [36]. The fluid found in e-cigarettes comprises numerous chemicals whose toxicity remains unknown [37]. The harmful effects of e-liquids can potentially elevate the risk of cardiovascular issues [38], even though long-term information on the safety of electronic cigarette liquids is incomplete. The risks associated with e-cigarettes encompass respiratory disease, cardiovascular disease, cancer, impacts on fertility, pregnancy, and various cardiovascular issues [12]. Chronic obstructive pulmonary disease, asthma, and respiratory system inflammation are among the disorders that might result from prolonged exposure to specific components found in e-cigarette aerosols [39]. Injuries to the lungs resulting from vaping can harm the alveolar-capillary barrier and disrupt respiratory volume distribution, mimicking atelectasis commonly observed in lipoid pneumonia cases. Apart from substances like THC, CBD, and opioids, standard components found in e-liquids like propylene glycol, vegetable glycerin, flavoring and coloring ingredients are major contributors to vaping-related lung injuries [40]. A major inflammatory lung disease called EVALI frequently necessitates hospitalization. The primary cause of EVALI is contamination of e-cigarette liquid with delta-9-tetrahydrocannabinol (THC) and vitamin E acetate, while there are other potential causes as well, such as specific compounds in vaping equipment. The diagnosis of EVALI depends on a history of suspicious vaping/dabbing use [41].

Direct exposure to e-cigarettes poses harm through both inhalation and absorption via the skin [42]. Short-term use of e-cigarettes presents lower acute risks to the cardiopulmonary system compared to traditional cigarettes. Transitioning chronic smokers to e-cigarettes over an extended period has the potential to diminish cardiovascular and lung damage, particularly in individuals grappling with asthma [11]. Heated tobacco products have the potential to introduce nicotine addiction to a new demographic of users [43]. Individuals who transition from smoking traditional cigarettes to using electronic ones may notice a decrease in negative effects, particularly concerning cardiovascular health. [35]. Heat-not-burn tobacco products are popular among people of all ages and non-smokers [44]. Six ingredients that are frequently present in e-cigarettes—nicotine, propylene glycol, glycerol, cadmium, ethylene glycol, nickel, aluminum, and titanium—have been linked to non-carcinogenic health hazards in users [45]. A quarter of smokers have never attempted Nicotine Replacement Therapy (NRT), electronic cigarettes, or heated tobacco products, while those who smoke lightly may lack motivation to quit [46]. Hence, there's a critical need to further enhance efforts aimed at reducing e-cigarette usage among adolescents. This includes refining knowledge, attitudes, intentions, perceptions regarding the risks of e-cigarettes, understanding mental health impacts, assessing drug use patterns, and continually enhancing related intervention strategies [44].

E-cigarettes exhibit higher acute toxicity compared to tobacco, yet their long-term toxicity remains uncertain or unexplored [42] or limited [11]. The complete cardiopulmonary effects of using e-cigarettes remain inadequately comprehended, and their long-term health impacts have not undergone comprehensive study. In vitro assessments indicate that elevated levels of nicotine delivered through aerosol might heighten the risk of nicotine poisoning and induce inflammation in the airways [47]. The existing health risk assessment studies concerning e-cigarette use are restricted and offer conflicting scientific evidence regarding

the understanding of health risks associated with their usage [45]. It's essential to standardize and validate analytical methods to ensure all products undergo meticulous and precise testing [47]. There's a necessity for experimental data that delves into the toxicological, immunological, and clinical impacts stemming from e-cigarette aerosols [39]. There remains a lack of standardized research methodologies in scientific studies addressing the toxicity profile associated with e-cigarettes [36]. A standardized assessment method is crucial to facilitate result comparison and timely updates for decision-making purposes [48]. Moreover, assertions regarding the potential use of e-cigarettes not just for recreational purposes but also as smoking cessation aids remain unverified and require scientific validation. The limited available data is somewhat conflicting or lacks robust power analysis to establish relevance [49]. Additionally, there is a pressing need for regulations governing electronic cigarette devices and e-liquids [50].

The discussion on tobacco harm reduction through e-cigarettes reveals a complex interplay between short-term benefits and significant health risks. E-cigarettes contain substances, such as metals and cardiotoxic compounds, leading to acute toxicity and adverse effects on the cardiopulmonary system, including reduced lung function and increased cardiovascular risks. While these risks extend to respiratory diseases, cardiovascular issues, and potential injuries like EVALI, a severe inflammatory lung condition, the effects on long-term health are still mostly unknown. Additionally, inconsistent evidence, limited research methodologies, and insufficient data on toxicity profiles demand standardized testing and regulatory measures for e-cigarette devices and liquids. Assertions regarding using e-cigarettes to quit smoking lack substantial scientific support, indicating a need for further rigorous research. The need for improved interventions, particularly for adolescents, to reduce e-cigarette usage remains a critical focus given the gaps in knowledge and understanding of their health implications.

Further research

Based on data from the Global Adult Tobacco Survey (GATS) in 2021, there has been an increase number of e-cigarette users in various countries. For instance, in Indonesia, the number of adult users of new e-cigarettes is approximately 5.58 million, marking a tenfold increase from 2011 (https://cdn.who.int). The significant global growth of e-cigarette users underscores the need for further research regarding these products from a health, social, policy, and economic perspective. Table 2 also indicates a scarcity of references related to e-cigarette in various countries, including Indonesia. According to [10], the chemical compound content in e-cigarettes may differ from country to country. his suggests the potential for researching the chemical compounds affecting health through human cell testing and establishing accepted chemical compounds by society, guided by health ministries' policies in each country.

Conclusion

The development of tobacco harm reduction methods has made significant progress over the past decade. Products such as e-cigarettes and e-liquids have become the focus of global research and discussion. It is critical to replace combustible tobacco products with non-combustible ones through tobacco harm reduction because it causes lower toxicity and risks. More than the last 2 decades there have been scientific publications mapped the dynamics of adoption and health impacts of this method in various countries.

The usage of e-cigarettes to lessen the harmful effects of tobacco is covered in this study; this is a topic that has seen a lot of investigation. While e-cigarettes and traditional tobacco products have been the subject of numerous studies comparing their health

concerns, further research is needed to fully comprehend the long-term health implications of e-cigarettes. There are still concerns regarding the possible hazards connected to its use, and further study is required to fully comprehend these effects. So, this study employs bibliometric and scientometric analysis to examine the hazards involved in using various goods, such as e-cigarettes and e-liquids. This analysis, which includes data from scientific literature, attempts to determine the field's trends. This research uses the Scopus database between 2009 – 2023 and bibliometric tools such as Biblioshiny and VOSviewer to visualize and analyze the data. The analysis includes a variety of keywords related to health risks, cancer, and e-cigarettes, providing insight into the current state of research in this area. The analysis includes a visual representation of document types, author keywords, international collaborations, and annual output of scientific research. The study also identified the writers who are most pertinent and affiliations, as well as scientific production by country. Word clouds and network visualizations show the most relevant words and their connection to research. This article also provides insight into the extent of international cooperation, productivity, and research focus in this area. Furthermore, it explores the correlation between Tobacco Harm Reduction and health risks, providing a list of articles covering topics such as e-cigarette use and other related subjects. This list offers crucial details for more study on these subjects, emphasizing the lack of study in Indonesia as a large population and a significant production of various tobacco products and derivatives. It also underscores the large consumption of tobacco products and types of tobacco harm-reduction products.

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Data availability statement

Since this is a systematic study, the paper and references contain all of the data.

Ethics statement

Since this study only uses published literature as a basis, an ethics statement is not relevant.

Credit authorship contribution statement

Bambang Prasetya: Conceptualization, Supervision. Biatna Dulbert Tampubolon: Conceptualization, Methodology, Formal analysis, Data Curation, Writing – Review and Editing. Ellia Kristiningrum: Conceptualization, Methodology, Formal analysis, Writing – Review and Editing. Teguh Pribadi Adinugroho: Writing – Original Draft. Widia Citra Anggundari: Methodology, Formal analysis, Writing – Review and Editing. Ary Budi Mulyono: Writing – Original Draft. Daryono Restu Wahono: Writing – Original Draft. Arif Nurhakim: Methodology, Data Curation, Visualization. Budhy Basuki: Writing – Original Draft.

Declaration of competing interest

The authors declare that none of the work reported in this study could have been influenced by any known competing financial interests or personal relationships.

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