

# Bibliometric Analysis and Visualization of Bayesian Network Application in Safety Field

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## Abstract

Bayesian network (BNs) has been widely used in uncertain knowledge modeling since it was proposed, especially in safety assessment and risk prediction. In order to fully understand the application status of Bayesian network in the field of safety, 3111 sample documents were collected from the web of science core collection database. Through CiteSpace technology text mining and visual analysis software, document output, keywords, author cooperation, organization cooperation, citation and journal distribution were analyzed. The results show that: FAISAL KHAN, MOHAMED ABDELATY, HELAI HUANG, TAREK SAYED, JAEYOUNG LEE, etc. published Bayesian networks The most widely used literature in the field of safety has made an important contribution to the development of this field; institutional cooperation is mainly based on Univ Central Florida, MEM Univ Newfoundland, Univ British Columbia, Tongji Univ, Texas A & M Univ, cents Univ, Delft Univ technology and other universities; journal distribution of literature is mainly based on the core functions of Bayesian network, and mainly distributed in ACCIDENT ANALYSIS AND PREVENTION, TRANSPORTATION RESEARCH RECODE, RELIABILITY ENGINEERING SYSTEM SAFETY and SAFETY SCIENCE.

## Keywords

Bayesian Network; Safety; Text Mining; Citespace; Visualization.

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## 1. Introduction

Bayesian Networks (BNs) are also called Belief Networks, Causal Probabilistic Networks, Directed Markov Fields, etc. [1], After fuzzy logic, credibility method and neural network method, another uncertain knowledge representation model, its concept was first given by Judea Pearl in 1988 [2]. It uses probability and statistics theory and graph theory as the theoretical basis. It uses a Directed Acyclic Graph (DAG) to express the dependency relationship between variables, and uses the Conditional Probability Table (CPT) to describe one of the variables. The joint probability distribution between. Because BNs have powerful modeling capabilities and intuitive expression capabilities, they can well solve the uncertainty of complex systems, so they have been widely used and have been successfully used in ecology [3] and reliability analysis [4], risk analysis and evaluation [5], information retrieval and meteorology [6] and many other fields. For example, Yu. DC [7] applied Bayesian network to evaluate the reliability of power system, and calculated the load loss probability according to the effective probabilistic reasoning algorithm in Bayesian network; Pasman [8] applied Bayesian belief network to Two gas stations and three hydrogen supply modes were used to carry out a case risk analysis; Tattari.S [9] used the Bayesian belief network model to evaluate the impact of the buffer zone on water resources protection and biodiversity. As the application scenarios of Bayesian networks continue to become more complex, classic Bayesian networks have shown greater limitations. For example, classic BNs did not consider the influence of time factors on variables when building models, leading to results There is a large error. So the researchers started again

improvements and innovations to BNs in order to adapt to more complex and changeable application scenarios. Later dynamic Bayesian networks (Dynamic Bayesian Networks, DBNs), Continuous Bayesian Networks (CBNs), Discrete Bayesian Networks (DBNs), Hybrid Bayesian networks (Hybrid Bayesian Networks) Networks, HBNs), Temporal Bayesian Networks (TBNs), Object Oriented Bayesian Networks (OBNs), and Dynamic Object Oriented Bayesian Networks (Dynamic Object Oriented Bayesian Networks, DOOBNs) and so on are the continuous innovation and improvement of Bayesian networks in actual case applications. In 1989, Dean and others conducted an extended study on the application of BNs in time series, extended the hidden Markov model, first proposed the concept of dynamic Bayesian networks, and then entered the research boom of DBNs. And gradually enter the practical application. For example, Wu Xianguo [10] and other step-by-step systematic decision-making methods based on dynamic Bayesian networks provide guidance for the dynamic safety analysis of road damage caused by tunnels over time, and accurately reflect the dynamics of geological, design and mechanical variables during the construction process. The change characteristics overcome the shortcomings of traditional fault analysis methods; Song Guozheng [11] et al. dynamically predict and diagnose abnormal events based on continuous Bayesian networks, overcome the shortcomings of traditional BNs, and make dynamic prediction and diagnosis analysis more reliable; Wang Yalan [12] et al. proposed a practical fault diagnosis method for chillers based on discrete Bayesian networks, which has strong robustness and efficiency; Stefan Mittnik [13] et al. demonstrated the use of hybrid Bayesian networks as a tool Map the causal dependence between the frequency and severity of risk events; Koller and Pfeffer first introduced the object-oriented Bayesian network, which was inspired by the idea of object-oriented programming in software engineering, and decomposed a complex BN For multiple reusable sub-networks, the hierarchical and block description of large complex systems makes the BN modeling work hierarchical and modular, and simplifies the network. These improved methods based on Bayesian networks are more suitable for dynamic, complex and changeable application scenarios, and have broader application prospects.

As one of the most effective theoretical models in the field of uncertain knowledge expression and reasoning, Bayesian networks are widely used in the fields of system reliability assessment, risk prediction, safety analysis and accident cause diagnosis. A. Bobbio [14] et al. studied the conversion method from fault tree to BN, and established a BN model equivalent to fault tree, which was used extensively in reliability analysis and safety analysis. It was to introduce BN into reliability and safety. One of the important research work in the field. Among the existing research work, Bayesian network is more as a clear method to solve specific problems. For example, Zhang Pan used fault tree analysis and Bayesian network methods to establish a channel conflict risk analysis model, and analyzed the channel conflict risk mechanism of a water airport; Liu Gang built a deep water well based on the fault tree model The control Bayesian network model identifies the main risk incentives for deep-water well control. As the application of Bayesian networks in the field of safety science becomes more and more mature, it is very important to summarize the current research work and explore the rules. Literature review is one of the important methods. For example, P. Weber [15] summarized the application of Bayesian networks in reliability, risk analysis and maintenance; Sohag Kabir [16] summarized Bayesian networks and Petri nets in system safety, reliability and The application of risk assessment analyzes the potential advantages of methods based on BN and PN over other classical methods. The method they used is a conventional literature review method, and the amount of literature that can be included is limited, mainly based on text descriptions, and it is difficult to clearly and comprehensively demonstrate the application of Bayesian networks in the safety field. In order to systematically and comprehensively study the application of Bayesian network in the safety field, this paper will use the method of scientific knowledge graph to visually display and analyze the collected sample documents.

## 2. Data sources and research methods

### 2.1 Data source

The quality of literature retrieval is the key to correctly drawing a knowledge map. In order to ensure the authority and accuracy of the literature, this article selects the documents in the Science Citation Index Extension (SCIE) and Social Science Citation Index (SSCI) in the Web of Science core collection database as The sample data draws a knowledge graph. Web of Science contains more than 12,000 high-impact journals and is considered to be the most comprehensive document database in the world [17]; SCIE and SSCI are the most commonly used databases in bibliometric analysis, covering more science and authority than other databases Publication [18]. Select Advanced Search on the Web of Science interface, set TS=("Bayes\*" AND "safety") to search, select "Article" OR "Review" for the document type, and set the year to all years (from the publication year of the Web of Science interface) The earliest published document was found in 1988), and the retrieval date was September 15, 2019. The content of the document download record was selected from the full record and the cited references, saved in a plain text format, and finally obtained the Bayesian network in the safety field. 3111 related documents are used, and the detailed information of document retrieval is shown in Table 1.

Table 1. Detailed information description of literature search

Search method	Advanced Search
Search type	Subject search
Language	All languages
Document type	Article OR Review
years	All years
Key words	“Bayes*” AND “safety”
Save format	Plain Text
Number of documents	3111 articles
Search date	September 15, 2019
Record content	Full records and cited references

### 2.2 Research methods

The paper uses the method of bibliometrics to study the application of Bayesian networks in the safety field, and displays relevant information by drawing the corresponding scientific knowledge graph. The concept of bibliometrics was proposed by information scientist Pritchard in 1969 [19]. It refers to the cross-science that uses mathematical statistics to quantitatively analyze all knowledge carriers. It has been gradually applied to energy and environment, economics and management, medicine, etc. Various research fields [20]. There are many softwares used in bibliometric analysis, such as HistCite, VOSviewer, Network WorkBench, DIVA, and CiteSpace [21]. This paper chooses CiteSpace software as the analysis tool. It is a visualization software developed by Professor Chen Chaomei of Drexel University and his team based on JAVA language [22]. It is combing the historical overview, evolution process and research frontiers of a certain research field. It has a unique advantage. Through the visual analysis of the literature on the application of Bayesian networks in the safety field, it seeks to grasp the development context of this field in a comprehensive and objective manner.

## 3. Results

### 3.1 Analysis of the author's cooperation network

The analysis of the author's cooperation network can identify the core authors of a discipline or field and the intensity of their cooperation, reflecting the clustering of scholars with the same or similar research directions, and providing academic exchanges and promotion Academic development is of great benefit.

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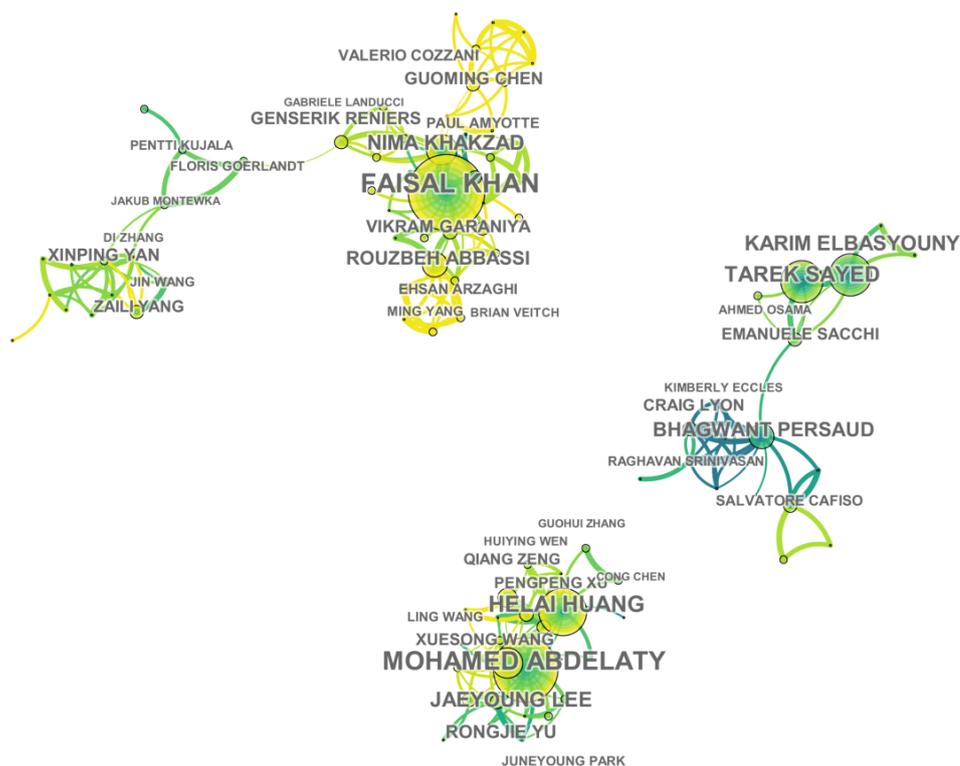


Figure 1. 2000-2019 Bayesian network document originator cooperation network (top 3)

Table 2. Ranking details of high yield authors (top15)

Serial number	Number of articles	Author	Year
1	70	FAISAL KHAN	2009
2	60	MOHAMED ABDELATY	2010
3	35	HELAI HUANG	2010
4	30	TAREK SAYED	2009
5	27	JAEOUNG LEE	2014
6	25	NIMA KHAKZAD	2013
7	24	KARIM ELBASYOUNY	2009
8	21	BHAGWANT PERSAUD	2007
9	19	ROUZBEH ABBASSI	2016
10	18	DOMINIQUE LORD	2008
11	15	RONGJIE YU	2012
12	14	PAIGE LEWIS	2015
13	14	VIKRAM GARANIYA	2015
14	13	XINPING YAN	2014
15	13	GUOMING CHEN	2018

The paper uses CiteSpace to visually analyze the authors of related documents from 2000 to 2019, and the generated author cooperation network is shown in Figure 1. Since the author's cooperation network is relatively scattered, the top 3 sub-networks in the author's cooperation network are selected for analysis. Each circular node in the network represents an author, the size of the node represents the number of papers published by the author, the connection between the nodes represents the cooperative relationship between the authors, and the thickness of the connection reflects the closeness of their cooperation. The color changes from cold to warm, indicating that the time of posting is from far to near. Select the top 15 authors with the number of publications as shown in Table 2. In terms of the number of papers published, the author with the largest number of papers published in the application of Bayesian Networks in the safety field is FAISAL KHAN, who

published 70 papers in 2009, followed by MOHAMED ABDELATY published 60 papers in 2010; HELAI HUANG published 35 papers in 2010; TAREK SAYED published 30 papers in 2009, etc. In terms of time, BHAGWANT PERSAUD, CRAIG LYON, TAREK SAYED and KARIM ELBASYOUNY are the authors of early research in this field, and the research of FAISAL KHAN, NIMA KHAKZAD, HELAI HUANG, JAEYOUNG LEE and MOHAMED ABDELATY runs through the entire development process of this field. , GUOMING CHEN and ROUZBEH ABBASSI are relatively active researchers recently. From the perspective of research themes, these three sub-cooperative networks are mainly divided into 5 research themes, as shown in Table N. A research team represented by FAISAL KHAN, MOHAMED ABDELATY, TAREK SAYED, XINPING YAN and GUOMING CHEN was formed.

### 3.2 Analysis of institutional cooperation network

Research institutions are an important platform for scientific research. The cooperation between institutions can clearly show the distribution of scientific research forces. The amount of articles published by an institution is an important indicator of its research capabilities. As shown in Figure 2, it is the institutional cooperation network, and the network tailoring chooses Pathfinder, Pruning sliced networks and Pruning the merged network.

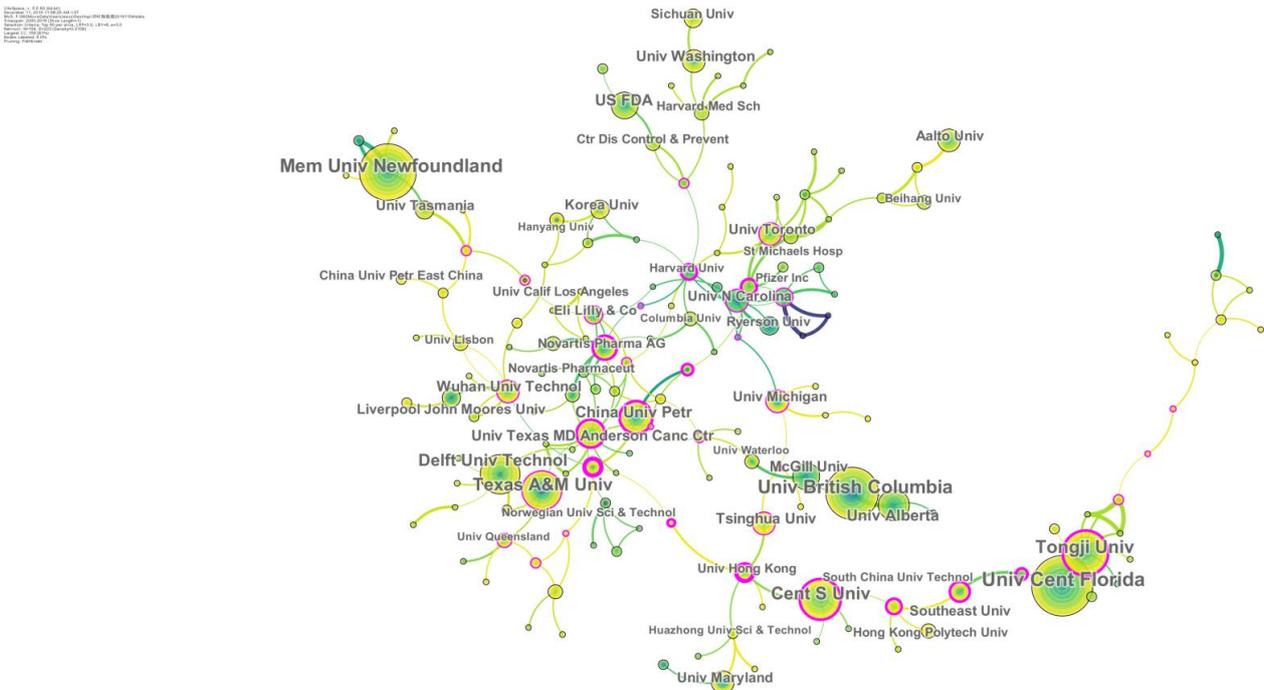


Figure 2. Application organization cooperation network of Bayesian network in safety field

The size of nodes and tags in the network is proportional to the amount of documents issued by the organization. The connection between nodes indicates that there is a cooperative relationship between organizations, and the width of the connection represents the strength of cooperation. From the perspective of the number of publications, the top five organizations with publication volume are Univ Cent Florida (73 articles), Mem Univ Newfoundland (61 articles), Univ British Columbia (55 articles), Tongji Univ (51 articles), and Cent S Univ. (41 articles). As shown in Table 3, the institutions ranked 6-15 in the number of articles published, the number of articles published by these institutions accounted for 18.2%, which is an important force in the application of Bayesian networks in the field of safety. From the perspective of the importance of institutions in the network, the nodes marked with purple circles in the figure are important nodes in the network, with high betweenness centrality ( $\geq 0.1$ ), and play a significant "media" role in the network. It can be seen from Figure 2 Tongji Univ (0.27), Cent S Univ (0.36), Texas A&M Univ (0.15), China Univ Petr (0.22), Univ Texas

MD Anderson Canc Ctr (0.23), Wuhan Univ Technol (0.19), Tsinghua Univ (0.15), etc. Has a high betweenness centrality, reflecting that these structures are in It has played a significant role as a bridge in the research cooperation in this field. In addition, there are some important nodes in Figure 2, which even have higher intermediary centrality. However, due to the small amount of publications issued by the institution, they cannot be shown in the figure. See Table 4 for specific information. Shows that there is no strict positive between the centrality of intermediary and the volume of publications Believe relations. Univ Cent Florida, Mem Univ Newfoundland and Univ British Columbia rank among the top three in terms of publication volume, but the overall intermediary centrality is relatively low. Cooperation and exchanges with other scientific research platforms should be strengthened to promote the flow of knowledge.

Table 3. Top 15 institutions in terms of volume

Serial number	Number of articles	Betweenness centrality	Institution	Year
1	73	0	Univ Cent Florida	2010
2	61	0.05	Mem Univ Newfoundland	2011
3	55	0.03	Univ British Columbia	2007
4	51	0.27	Tongji Univ	2013
5	41	0.36	Cent S Univ	2014
6	40	0.15	Texas A&M Univ	2007
7	36	0.07	Delft Univ Technol	2009
8	28	0.22	China Univ Petr	2011
9	28	0.02	Univ Alberta	2012
10	28	0.02	US FDA	2011
11	23	0.23	Univ Texas MD Anderson Canc Ctr	2015
12	23	0.19	Wuhan Univ Technol	2014
13	23	0.15	Tsinghua Univ	2017
14	21	0.05	McGill Univ	2010
15	21	0.02	Univ Washington	2011

Table 4. Top 10 institutions in terms of centrality

Serial number	Betweenness centrality	Number of articles	Year	Institution
1	0.48	13	2016	Univ Hong Kong
2	0.43	12	2014	Norwegian Univ Sci & Technol
3	0.36	41	2014	Cent S Univ
4	0.33	11	2017	South China Univ Technol
5	0.33	3	2019	Southwest Jiaotong Univ
6	0.32	11	2013	Harvard Univ
7	0.29	19	2014	Southeast Univ
8	0.28	6	2011	Natl Univ Singapore
9	0.27	51	2013	Tongji Univ
10	0.27	6	2015	Jiangsu Prov Collaborat Innovat Ctr Modern Urban

### 3.3 Analysis of Journal Co-citation

Journals are the main carrier of scientific research results. High-impact journals in this field can be identified through journal co-citation analysis. Figure 3 shows the co-citation network of Bayesian network applications in the safety field. The node size represents the citation frequency of the journal. According to the data derived from Web of Science, more than 1,000 publications have published related documents in this field so far. The top five in this field are ACCIDENT ANALYSIS AND PREVENTION (244 articles) and TRANSPORTATION RESEARCH RECORD (167 articles). ), RELIABILITY ENGINEERING SYSTEM SAFETY (115 papers), SAFETY SCIENCE (89 papers)

and JOURNAL OF LOSS PREVENTION IN THE PROCESS INDUSTRIES (51 papers), other journals have less than 50 papers. Table 3 lists the relevant information of the top 10 cited journals. From Table 5 and Figure 3, we can see that the highly cited journals and the high-volume journals are basically the same; NEW ENGLAND JOURNAL OF MEDICINE (3 articles), JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION (6 papers), JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION (5 papers) and other journals have very low articles, but the citation frequency is high, indicating that their articles are of high quality and are authoritative journals in the field, Has been recognized by more peers.

Table 5. Top10 relevant information of cited journals

Journal	Cited frequency	Year	Number of journal articles
ACCIDENT ANALYSIS AND PREVENTION	739	2001	244
RELIABILITY ENGINEERING SYSTEM SAFETY	620	2002	115
SAFETY SCIENCE	596	2005	89
TRANSPORTATION RESEARCH RECORD	578	2001	167
STATISTICS IN MEDICINE	564	2001	44
NEW ENGLAND JOURNAL OF MEDICINE	544	2001	3
LANCET	394	2001	12
JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION	360	2001	6
RISK ANALYSIS	344	2002	40
JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	299	2001	5

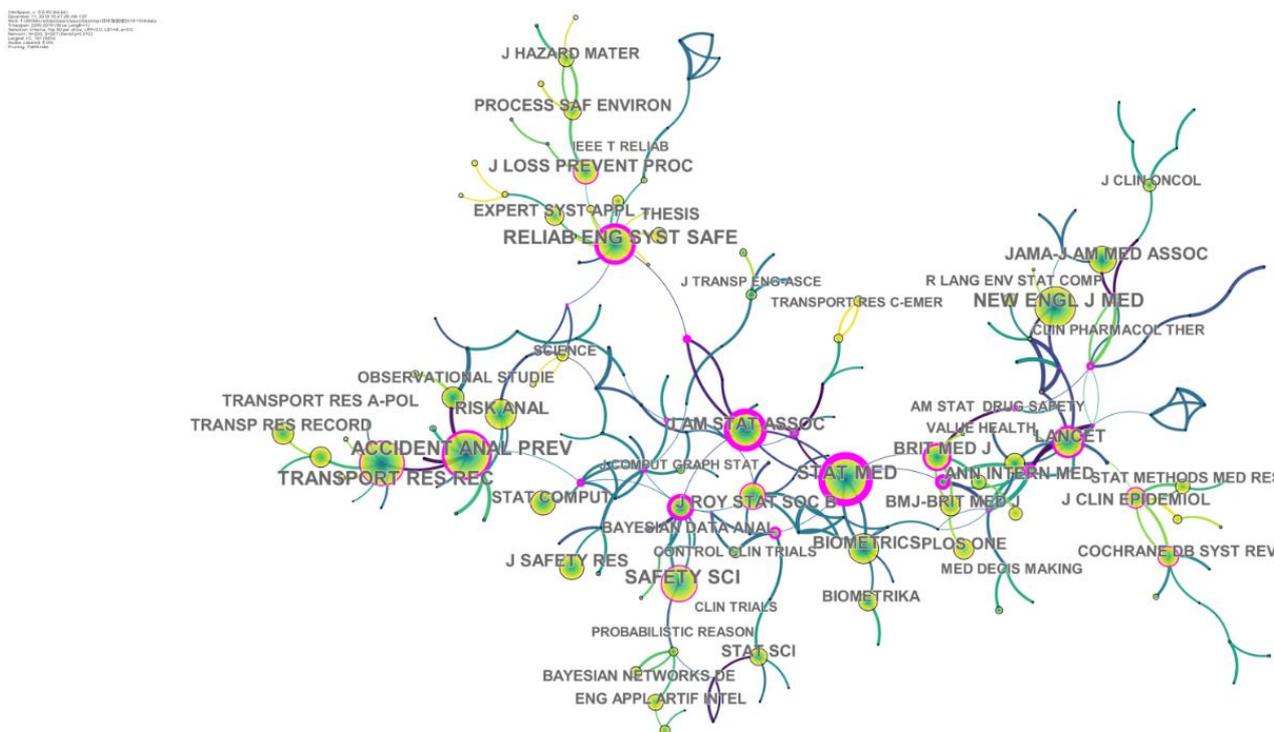


Figure 3. Journal co-citation network of Bayesian network in safety field

### 3.4 Keyword Co-occurrence Network

Keyword is one of the important ways of document retrieval. The idea of co-occurrence analysis of keywords originates from document co-citation and document coupling theory in bibliometrics. The so-called co-occurrence analysis technique is through the analysis of the connection strength between the representative terms of the relevant literature. Although the proportion of keywords in an article is very small, it is the core and essence of the article. It is a high level of generalization and condensing of the topic of the article. Therefore, keyword analysis can be used to identify the continuous



supply chain project based on the safety inspection records of 6 supply chain construction projects and 9 projects with on-site accidents. safety risk assessment model. Yan Zhengbing [26] proposed a reconstruction method based on Bayesian lasso, which transformed the problem of statistical fault isolation into the problem of variable selection in regression analysis, and effectively solved the problems of insufficient historical data and tailing effects. Ahmed Mohamed M [27] et al. used empirical Bayesian methods to study the safety impact of red light cameras on traffic accidents at signalized intersections.

Table 6. Details of high frequency keywords (&gt; = 47 times)

Keyword	Frequency	Betweenness centrality	Year	Keyword	Frequency	Betweenness centrality	Year
safety	580	0.03	2000	trial	73	0.06	2004
model	393	0.07	2000	network meta-analysis	70	0.05	2016
bayesian network	342	0.08	2006	identification	69	0.12	2004
system	217	0.16	2002	frequency	67	0.02	2008
efficacy	189	0.19	1999	impact	66	0	2010
risk	178	0.07	1998	severity	63	0.04	2010
double blind	149	0.14	2007	regression	63	0	2007
management	144	0.16	2004	safety analysis	63	0.03	2008
clinical trial	136	0.04	1999	meta-analysis	60	0.11	2007
accident	135	0.14	2007	bayesian	59	0.11	2005
reliability	135	0.07	2004	framework	57	0.01	2010
prediction	130	0.12	2006	probability	55	0.26	2002
risk assessment	116	0.03	2005	bayesian analysis	54	0.08	2003
risk analysis	116	0.09	2002	network	51	0.06	2008
design	114	0.04	1999	performance	49	0.07	2009
uncertainty	89	0.08	2004	fault tree	48	0.01	2009
therapy	85	0.28	2005	empirical bayes	47	0.18	2005
bayesian inference	77	0.02	2008	bayesian method	47	0	2007

### 3.5 Document co-citation analysis

The total citations of the literature reflect the knowledge base of a discipline or a research field. Knowledge base is conducive to further clarifying the essential concepts of research hotspots. If the research front is defined as the development status of a research field, then the citations of the research front constitute the corresponding knowledge base [28]. Co-citation analysis of documents can discover the knowledge base of a certain research field. Using CiteSpace technology text mining and visual analysis software to generate a document co-citation network for the application of Bayesian networks in the safety field is shown in Figure 5. The size of the node in the graph indicates the frequency of citation (CF) of the document. The larger the node, the higher the citation frequency of the document. At the same time, the nodes with higher citation frequency and high betweenness centrality are considered to be research hotspots. Table 7 lists the detailed information of the top 10 cited documents. First, a paper by Dominique Lord [29] discussed the factors that affect the likelihood of a vehicle collision in the absence of detailed driving data. The comparison with Gamma model, Random-effects models, Finite mixture/Markov switching models and other models highlights the advantage of Bayesian network model as a forecasting tool. Georgia Salanti [30] and others used Bayesian methods to conduct different antiplatelet intervention trials on the incidence of serious vascular events in random events MTM, and explored the advantages and disadvantages of various traditional and new forms of quantitative display and graphical presentation. In 2011, Nima Khakzad [31] discussed the safety analysis in the processing of natural gas facilities, and compared the fault tree and Bayesian network methods. The Bayesian method can explicitly express the dependence between events and update the probability. And to deal with uncertainty, it is widely used in dynamic system analysis.

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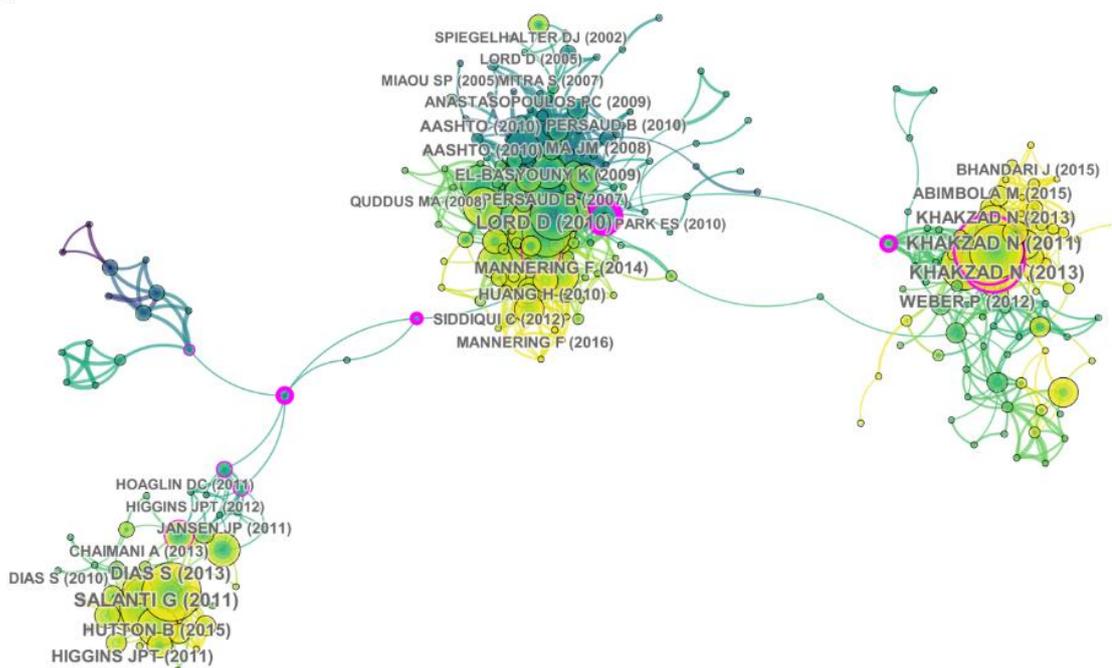


Figure 5. The application of Bayesian network in safety field

Table 7. Top 10 cited literature details

Frequency	Betweenness centrality	Author	Year	DOI
104	0.19	Salanti G	2011	<a href="https://doi.org/10.1016/j.jclinepi.2010.03.016">10.1016/j.jclinepi.2010.03.016</a>
103	0.55	Khakzad N	2011	<a href="https://doi.org/10.1016/j.res.2011.03.012">10.1016/j.res.2011.03.012</a>
102	0.02	Lord D	2010	<a href="https://doi.org/10.1016/j.tra.2010.02.001">10.1016/j.tra.2010.02.001</a>
98	0.26	Khakzad N	2013	<a href="https://doi.org/10.1016/j.psep.2012.01.005">10.1016/j.psep.2012.01.005</a>
85	0.02	Dias S	2013	<a href="https://doi.org/10.1177/0272989X12458724">10.1177/0272989X12458724</a>
66	0.21	Khakzad N	2013	<a href="https://doi.org/10.1016/j.ssci.2013.01.022">10.1016/j.ssci.2013.01.022</a>
62	0.02	Hutton B	2015	10.7326/M14-2385
58	0.07	Weber P	2012	<a href="https://doi.org/10.1016/j.engappai.2010.06.002">10.1016/j.engappai.2010.06.002</a>
55	0.04	Higgins JPT	2011	<a href="https://doi.org/10.1136/bmj.d5928">10.1136/bmj.d5928</a>
53	0	Mannering F	2014	<a href="https://doi.org/10.1016/j.amar.2013.09.001">10.1016/j.amar.2013.09.001</a>

### 3.6 Analysis of Country/Region Cooperation Network

The cooperation network between countries/regions shows the layout of scientific research forces at a macro level. Figure 6 shows the national/regional cooperation network for the application of Bayesian networks in the safety field. The size of the nodes in the figure represents the number of documents published by the country. The purple circle (intermediary centrality  $\geq 0.1$ ) is a high-influence country/region, and the connection between the nodes represents the cooperative relationship between the countries/regions. From the perspective of the number of publications, the USA ranked first with an absolute advantage of 1,216 articles, nearly twice as much as the second place, and PEOPLES R CHINA (621 articles) and ENGLAND (353) ranked 2nd to 5th. Articles), CANADA (332 articles) and FRANCE (153 articles); from the perspective of national/regional influence, USA (0.28), CANADA (0.23), SPAIN (0.17), ITALY (0.13), NETHERLANDS (0.12), Countries/regions such as GERMANY (0.12), FRANCE (0.1), and ENGLAND (0.1) have intermediary centralities greater than 0.1. They are highly influential countries/regions, and these countries/regions have played a leading role in the development of this field. Role; China ranks second with 621 articles published, but its intermediary centrality is only 0.03, and it has not been selected as a high-impact country/region. China should actively participate in international

cooperation, broaden international perspectives, and strive to improve the quality of scientific research output; In terms of the degree of cooperation between countries/regions, in this field of research, countries have established relatively extensive cooperative relations, with a network density of 0.2739. Among these cooperative relations, Germany and AUSTRALIA, JAPAN and NORWAY, ENGLAND and NETHERLANDS, etc. The cooperation relationship is closer. Among them, ENGLAND and NETHERLANDS are the countries that established the cooperative relationship in the early stage; from the perspective of time distribution, the countries/regions distributed in 2000-2005 mainly include USA, ENGLAND, PEOPLES R CHINA, CANADA, FRANCE, and ITALY, etc. , They are the early countries that made outstanding contributions in this field, and they are also the main force of high influence and high output of literature. The countries/regions distributed in 2006-2010 mainly include AUSTRALIA, GERMANY, SPAIN, BELGIUM and JAPAN, etc., the countries/regions distributed in 2011-2015 mainly include DENMARK, PORTUGAL, INDIA and POLAND, etc., and the countries/regions distributed in 2016-2019 mainly include SERBIA, TUNISIA, CHILE and EGYPT.

Table 8. Top 15 countries / regions

Serial number	Number of articles	Betweenness centrality	Country/Region	Year
1	1216	0.28	USA	2000
2	621	0.03	PEOPLES R CHINA	2004
3	353	0.1	ENGLAND	2000
4	332	0.23	CANADA	2001
5	153	0.1	FRANCE	2005
6	151	0.13	ITALY	2001
7	146	0.07	AUSTRALIA	2006
8	142	0.12	NETHERLANDS	2000
9	113	0.12	GERMANY	2007
10	113	0.05	SOUTH KOREA	2005
11	88	0.17	SPAIN	2006
12	88	0.05	SWITZERLAND	2002
13	63	0.06	BELGIUM	2006
14	63	0	JAPAN	2006
15	52	0.05	SWEDEN	2000



Figure 6. National cooperation networks

## 4. Conclusion

This paper analyzes the application status of Bayesian networks in the safety field from the perspective of bibliometrics, using CiteSpace technology text mining and visualization analysis software to analyze the output trend of relevant literature on the application of Bayesian networks in the safety field, and keyword co-occurrence networks, Author cooperation network, institution cooperation network, national cooperation network, document co-citation network and journal co-citation network carried out a series of visual display, and came to the following conclusions:

(1) From the perspective of the distribution of scientific research power, at the national level, USA is a high-yield and high-influential country. Other high-influential countries include CANADA, SPAIN, and ITALY. China ranks second with 621 articles published, but its influence is low. The quality of scientific research output needs to be improved; at the institutional level, Univ Cent Florida, Mem Univ Newfoundland, Univ British Columbia, Tongji Univ, Texas A&M Univ, Cent S Univ, and Delft Univ Technol are high-yield institutions; the author's cooperation network is relatively scattered, so selected The top three cooperative networks, FAISAL KHAN, MOHAMED ABDELATY, HELAI HUANG and TAREK SAYED have published the most papers.

(2) From the perspective of keyword analysis, the application of Bayesian networks in the safety field mainly focuses on risk assessment and prediction, accident cause diagnosis, system safety analysis and reliability analysis, etc. Its improvement and innovation are reflected in Combination with traditional fault tree model, bow tie model and application of dynamic Bayesian network.

(3) The application of Bayesian networks in the safety field has published a lot of highly cited documents, which form the knowledge base of the research in this field. These highly cited documents mainly describe the advantages of Bayesian networks compared with traditional methods and their applications in specific cases. They have strong practicability, and theoretical innovation needs to be strengthened; ACCIDENT ANALYSIS AND PREVENTION, TRANSPORTATION RESEARCH RECODE, RELIABILITY ENGINEERING High-impact journals such as SYSTEM SAFETY and SAFETY SCIENCE are the main knowledge dissemination carriers for the application of Bayesian Networks in the safety field, reflecting its core functions.

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