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Liability of Artificial Intelligence System: A Bibliometric Study of Current and Emerging Trends (2011–2024)

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The Integration of Artificial intelligence across the various sector such as Transportation as Autonomous vehicle, Business, education and healthcare has introduced the remarkable efficiencies such as data interpretation, data analysis, predictive analysis and Advance decision making, however it also purposed the unprecedented Legal issues. The Artificial intelligence system has become autonomous and obtained the capability of self decision making from the data. These advances of the AI system challenged the various aspect of Legal framework such as Insurance policy, intellectual property in AI and the Liability in case fault. The question of liability has become pressing concern because the Black box nature of AI and the involvement of various stakeholder complicated the assignment of legal responsibility in case of Failure. The present study aimed to investigate the research landscape including the knowledge, emerging area and the trends available in the literature on the Artificial intelligence liability. This research adopted the Bibliometric analysis methodology using the R software Biblioshiny Package, the analysis conducted on Liability focused studies related to artificial intelligence from timespan of 2011-2024. A total 154 document were obtained from the scientific databased SCOPUS and Web of Science after rigorous manual review of keywords "Liability and Artificial intelligence" in Title and abstract. This study employed the several analyses on the data including growth of research area, leading document, distribution of studies by the author, leading county, collaboration network, trend topic and factorial analysis. The finding indicates a notable increase in the number of publication form 2011-2024 focusing the healthcare sector. The emerging research area includes the area such as insurance, product liability, civil liability, strict liability of artificial intelligence. The study underscored the AI rule, regulation framework underdeveloped which require the further study in relation of legal liability. Finally, the findings suggest that the increasing focus on liability framework will foster the trustworthy AI and better regulating policies.

Keywords: Artificial Intelligence, Liability, Healthcare, Autonomous Vehicle, Bibliometric Analysis

The integration of artificial intelligence (AI) across the various crucial sectors such as healthcare, education, transportation created the fourth industrial revolution. Which is supported by the substantial advancement such as availability of data, advanced algorithm and design and processing power which lead the adoption of AI into these filed and resulted the fast result and more effective predictive analysis.[1, 2]

There is no functioning legal definition of Artificial intelligence stated under the act or any law however in science term the AI is defined as the system that posses the ability to act by think own and rationalize in a manner of mimic like human intelligence, this possesses both the cognitive and the behavioral ability and possess the ability to learn from the data and train itself, store the personal experience for the further enhancement. This nature of working Programme with such ability makes it different from the conventional algorithm,[3, 4] where the traditional algorithms required human interface to run the AI algorithms possess autonomy. Further, the AI is categorized into 3 different categories according to their ability to perform the task and autonomous behavior A) Artificial narrow intelligence or (WAI) weak AI b) AGI or Artificial general intelligence or Strong AI and C) (ASI) or Artificial super intelligence.[5] Based on intelligence AI is classified into three categories 1) Artificial narrow intelligence or weak AI 2) Artificial general intelligence (AGI) or Strong AI and 3) Artificial Super Intelligence (ASI).[5] On the basis of these types the applicated span in various field such as predictive analytic in healthcare and personalized treatment plan created with Strong AI. The application of Advance software in Vehicle or autonomous. In legal filed the EU enacted the first AI act in august 2024, the framework define the AI as the "An AI

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system is a machine-based system designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment and that for explicit or implicit objectives, infers from the input it receives, how to generate output such as prediction, content, recommendations or decision that can influence Physical or virtual environment".[6] Which clearly depict that the AI can also include the self-learned ability Programme and able to learn the activities which is beyond the human working capability such as to work autonomously.[7]

This has opened the different perspective in the from od debate on the new challenges and opportunity of the AI. From leveraging federated learning to combat food fraud in supply chains to enhancing production and manufacturing processes, weather forecasting, predict an epidemic, improve industrial productivity.[8, 9]

Liability is a fundamental concept within the field of legal science, and its judicious and suitable application both domestically and internationally plays a crucial role in bolstering the legal framework.[10, 11] In the realm of jurisprudence, the term "legal responsibility" pertains to the legal obligation that an individual bears for their actions or lack thereof. This responsibility frequently results in the imposition of compensation, fines, or punitive measures.[12] Various jurists have provided distinct definitions of liability within diverse contexts. According to Salmond's legal theory, liability refers to the legal relationship that exists between a wrongdoer and the remedy. Austin provided a definition of liability as the consequences that a wrongdoer must face as a result of their breach of duty or actions. This definition emphasizes that liability arises from a wrongdoing or breach of duty in the legal context.

The categorization of liability can be broadly classified into two primary categories Civil and Criminal. Civil liability refers to the legal accountability of the individual or entity that has committed an act of wrongdoing. This encompasses various forms of tort liability, including negligence, defamation, and intentional harm, as well as breach of contract. The aforementioned liability serves the purpose of guaranteeing that the aggrieved party is afforded a redress in the guise of monetary reparation and losses[13, 14] whereas, the criminal liability arises from the violation of criminal laws, leading to penalties such as fines, imprisonment, and in severe cases, the death penalty. In such cases, the state prosecutes the offender to administer punishment.[15] However, in the case of AI imposing the liability is one of the critical because of its autonomous nature and involvement of various member, the old theories of the Liability cannot be seen in the modern act of the AI because of the set Factor in order to decide the liability.

While AI is being widely embraced across different industries; healthcare is witnessing a significant growth in the adoption of AI technologies. These systems, include decision support tools to autonomous diagnostic algorithms, offer significant benefits but also carry risks, particularly when they operate without transparent reasoning.[12] The opacity of AI decisions in clinical settings can lead to significant consequences for patient care, highlighting the need for thorough supervision by clinicians.[13] The use of AI in clinical practice has raised questions about liability for medical errors resulting from care jointly delivered by physicians and algorithms. Given the relatively recent emergence of AI in healthcare, there is little established case law about how liability issues should be adjudicated.[14] AI Liability issues are not limited to healthcare but also affect other sectors such as autonomous vehicles and maritime navigation. The International Maritime Organization defines Maritime Autonomous Surface Ships (MASS) as vessels capable of varying degrees of autonomous operation, raising questions about liability for accidents.[15] Similarly, the legal responsibility for accidents involving autonomous vehicles remains a contentious issue, with ongoing discussion about the most appropriate liability rule[16] These scenarios underscore the importance of comprehensive legal frameworks that effectively address the risk associated with AI systems.[17]

The impact of Artificial intelligence on the policies and regulation orders to uphold the rules of Law. EU being the first country to adopt the AI act 2024 also prosed the AI liability directive and the product liability directives, later retracted due to unclear liability terms reflect the progress toward the AI regulatory Approach to risks.[18] These proposed terms also posse the gaps such as complexities of Medical AI liability, dealing with the healthcare and autonomous vehicle require an extra care to decide the liability regulations because it directly poses the risk of life.[19, 20] In term of Autonomous AI system, the differentiation between the fully autonyms system is necessary while the assistive tools and chatbot support the human decision. The autonomous AI systems independently perform the task such as Autonomous vehicle developed by Teska, Waymo and cruise which use the combination of sensor and machine learning algorithms for the advance decision-making models to navigate the road. Detect the obstacles

and work on real time data without any human intervention.[15] this has challenged the raising different regulatory and liability.[21] What if AI system causes the failure and cause harm due to any error? What if the AI is being misused? This underscores the importance of clear legal liability approach to ensure the proper accountability and the victim compensation.[22, 23] and as these technologies will get advance then the web of liability will become complex to understand and make the various stakeholders liable.[24]

This adoption of AI and issue of Liability underscored the need for Bibliometric analysis on Artificial intelligence liability to find the leading contributor to understand their approach towards AI liability, to find leading country to understand the variety of legal framework and the highly impacted documents cover the various civil and criminal liability approach.

Research Question

Considering this issue the research tried to answer the following questions-

RQ1- who are the leading Authors working on the AI liability Approach

RQ2: What are the most influential journals, institutions, and countries contributing to the literature on AI liability from 2011 to 2024?

RQ3: What are the emerging and most frequently explored themes in AI liability research, as revealed through keyword co-occurrence and thematic analysis?

RQ4: How has the volume and focus of research on AI legal liability evolved over time, and what are the publication trends across different years?

Materials and Methods

To conduct the analysis the study adopted the Methodology suggested by Rowley and Slack.[26] This is widely methodology accepted by the various research to conduct the bibliometric analysis research across various filed.[27-29] The steps wise procedure has been followed to ass the retrieved literature on AI and liability. As a part of relevant data various set of filters used to ensure that only relevant research comes for the bibliometric and networking mapping tools for carrying out the research study. The Detailed selection, retraction and application of filter using PRISMA is shown in Fig. 1 which explains the methodology for the research study.[36]

Step 1: Identification and Selection of the Database for Literature Search

Started with the first step the two strong scientific database is selected to search the literature around AI liability, SCOPUS AND WOS web of science are the leading database for the essential resource in academic research, both the database offers the broad range of scholarly literature from the reputable published and also ensures the credibility of information. They streamline the literature for the bibliometric Studies with the advance search filters and enable to import the data into various form.[30]

Step 2: Search Syntex

After the selection of database, the selection of search Syntex is another crucial step in bibliometric study. A good Syntext helps to search he all relevant research documents with the selected knowledge

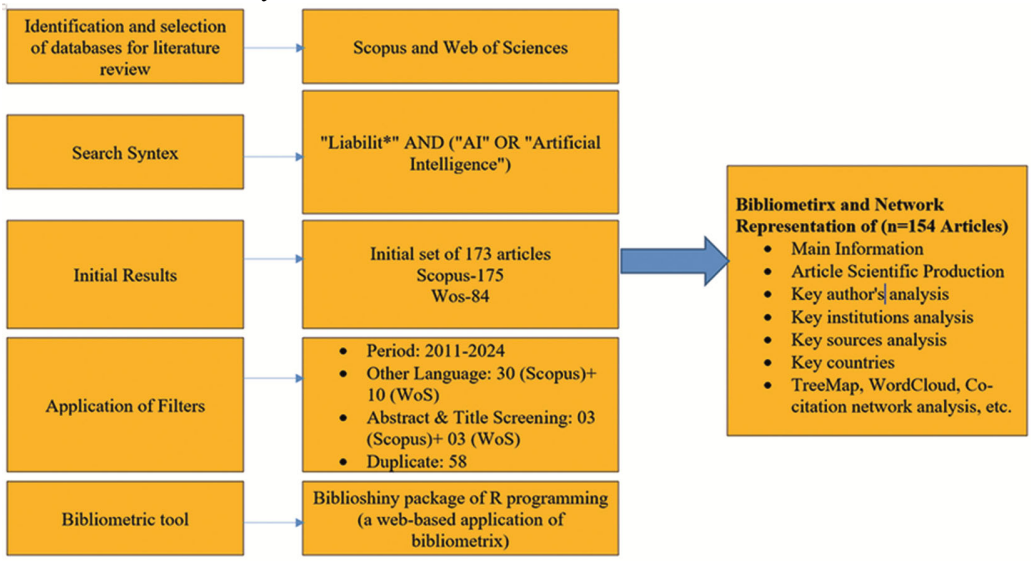

Fig. 1 — Research methodology for bibliometric analysis

domain. For the purpose of this research the search for literature is utilize the keyword string as ("AI", “artificial intelligence” and "Liability”) to ensure the coverage of all related document in this filed. The investigation period for this Syntex spanned from 2011-2024 as the relevancy of the document and the search query was executed on January 24, 2024.

Database	Search Syntext
Scopus (https://www.scopus.com)	TITLE (“Liabilit*" AND (“AI" OR "Artificial Intelligence")
WoS (https://www.webofscience.com)	"Liabilit*" AND ("AI" OR "Artificial Intelligence") (Title)

Step 3: Initial Results of the Literature Search

The initial result around the AI liability search in title found 173 documents in scopes and 85 documents in WOS. To focus on the relevant document the search query TITLE ("Liabilit*" AND (("AI" OR "Artificial Intelligence") narrowed down to the title only after the manual checking of keyword Artificial intelligence and liability in the title and abstract.

Step 4: Application of Filters

Several filters were applied to the original dataset to make it better for in-depth analysis of the research literature. At first, stories from 2011 were included to show how liability in artificial intelligence has changed over time. During the extraction process, the first filter was used to keep only English-language articles. With these filters in place, 160 study papers from Scopus and 78 from WoS were chosen. Then, the datasets from both databases were checked for duplicates. It was found that 57 WoS works were already in the Scopus dataset. So, the end dataset was made up of 181 research papers from Scopus, with duplicates removed using the R programming language.

Step 5: Bibliometric Tool

For the final meta data analysis retrieved from the SCOPUS and WOS R-studio bibliometric package "Biblioshiny" was utilized for full bibliometric analysis. The R is an open-source computer language and environment that is at the heart of Biblioshiny. Aria and Cuccurullo's major work,[31] which has since become a standard in the field, paved the way for this method. Three main steps were taken in this study based on their framework. To begin, the data gathering part included getting the data, loading it, converting it, and cleaning it up. This important first step made sure that the information was correct and of good quality. After that, the second step was a thorough study of the data, which included both descriptive and citation analyses, to find patterns and trends in the literature. In addition, the step of data visualization brought ideas to life through different kinds of graphs. Conceptual maps, keyword groups, co-occurrence networks, histography networks, and country-based affiliation networks were some of these. As suggested by Garza-Reyes[32], great care was taken to narrow down the search phrase, find the first paper, improve the results, and gather basic data before moving on to these steps.

Result and Analysis

Overall Review of the Database

The result of bibliophily R package tool for exploratory study of the data of “AI liability" is presented in Table 1. Based on information gathered from 2011 to 2024, a full analysis of 154 pieces about AI liability was carried out. The publications came from 117 different sources, found in the Scopus and Web of Science databases. There was an average of 2.45 papers published each year, which means that scientific goods grew by 26.84% each year. On average, 6.429 citations were given to each paper. (See Fig. 2) There were 279 authors, but only 67 of them were released as single authors. The fact that 8.442% of the papers were written by people from other countries shows that AI liability is a new topic in academia. Total 91 article found where the other documents include the book chapter, conference paper, review article. Figure 3 shows the growing interest of research in this domain.

Annual Scientific Production and Average Citation

The analysis of annual scientific production is presented in Table 2 and Fig. 4, which shows the increasing number of research document, where there was N=1 article in 2011 related to AI liability, the number of publications has increased to N=18 in 2020, N=25 in 2021, N=35 in 2022 and N=38 in 2023, the number is raised to N=22 till January in 2024. The Average citation is shown in Fig. 5 to record the impact of publication, 2014-2016 recorded the high impact document, though the number of publications is increased after 2020 but the impact of the document recorded less.

Table 1 — Main Information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2011:2024
Sources (Journals, Books, etc)	117
Documents	154
Annual Growth Rate %	26.84
Document Average Age	3.45
Average citations per doc	6.429
References	3174
DOCUMENT CONTENTS	
Keywords Plus (ID)	266
Author's Keywords (DE)	288
AUTHORS	
Authors	279
Authors of single-authored docs	67
AUTHORS COLLABORATION	
Single-authored docs	71
Co-Authors per Doc	2.05
International co-authorships %	8.442
DOCUMENT TYPES	
article	91
article conference paper	1
article; book chapter	1
article; early access	3
book	2
book chapter	20
book review	3
conference paper	18
correction	1
editorial	1
editorial material	6
erratum	1
note	1
proceedings paper	1
review	4

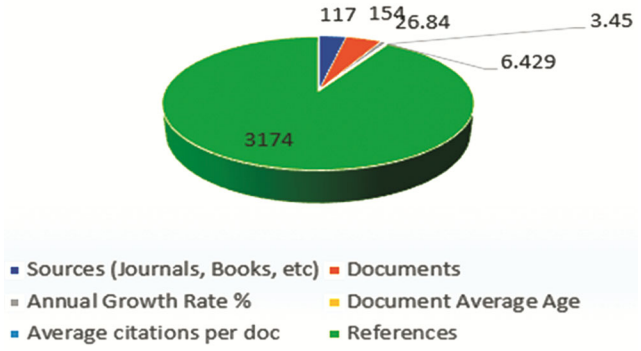

Fig. 2 — Main information of Data

Three plot study Most Frequent Relationship with the Authors Sankey Diagram

The three parameters related to the authors document title and authors university has been selected to conduct the three-plot study for most frequent relationship Fig. 6

The diagram provided a rich visual representation of the interconnected relationships between the institution, author and the title of the documents. Around the artificial intelligence and liability at the center of the diagram, the key terms such as artificial intelligence, liability and AI appear as the dominant theme around the topic focused on in this scholarly disclosure While the core concept are linked to a wide

Table 2 — Annual scientific production

Year	Articles
2011	1
2012	0
2013	1
2014	1
2015	2
2016	0
2017	1
2018	4
2019	9
2020	18
2021	25
2022	32
2023	38
2024	22

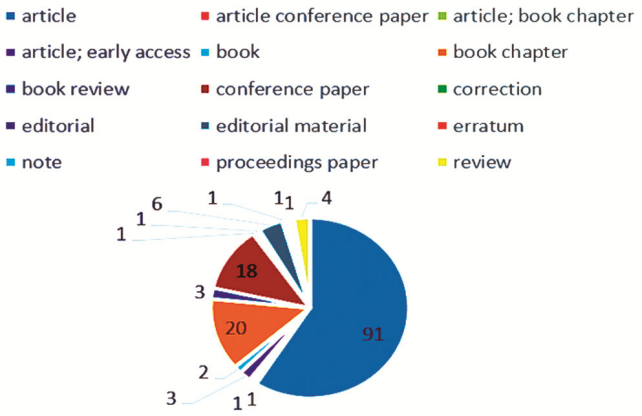

Fig. 3 — Document types found in Main Information

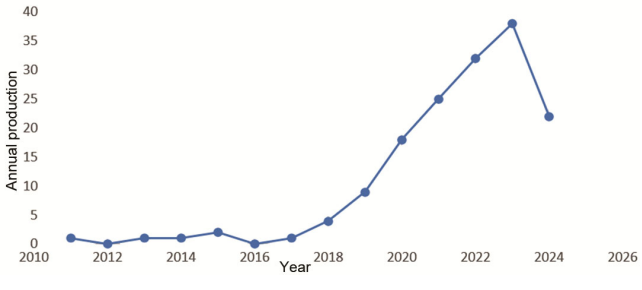

Fig. 4 — Annual scientific production

range of authors, including Gerke S, Cohen I, Wendehorst C and Bottomley D Which shows the most contribution coming from these authors The term such as civil medical system, autonomous suggests that a Multidimensional exploration of air liability a particularly in the critical sectors such as healthcare, transportation and regulatory context. Overall, this highlighted data collaborative and interdisciplinary nature in the artificial intelligence liability research. This reveals a complex and evolving network which is dedicated to address the legal, ethical and societal implication of the artificial intelligence

Most relevant Source, Author and Affiliations and Collaboration Network

The findings of the publications incorporated in the study, within the scope of most relevant Sources, Authors and Affiliations. Upon the examination of the publication on AI Liability from the 137 sources, the top ten most relevant sources of scientific publications shown in (Fig. 7). The European Review of Private Law, and, Law, Governance and Technology Series identified as the top relevant source with (N=5) publication, followed by Computer Law & Security Review and Tort Liability & Autonomous System Accidents: Common and Civil Perspectives, with the (N=4) publications.

A total of (N=279) authors published 157 scientific productions related to AI liability in different publication venues. Where Gerke S. is the most productive author with (N=5) publications, (1.92 Fractionalized Value) shown in (Fig. 8), Followed by Kochi B and Wendehorst C with (N=4) publication and (1.23 Fractionalized Value), (2.39 Fractionalized Value). Other most relevant authors are Bottomley D, Cohen I, and Duffourc M with (N=3) publication.

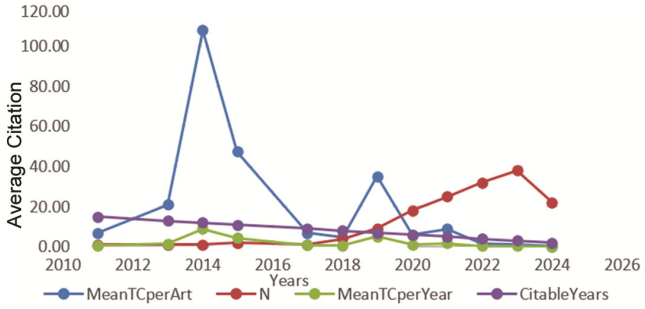

Fig. 5 — Average citation per year

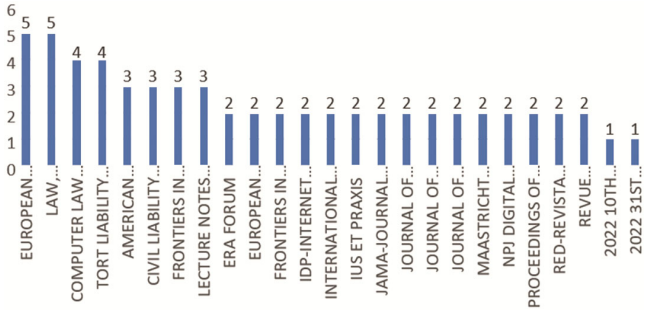

Fig. 7 — Top ten Most relevant sources

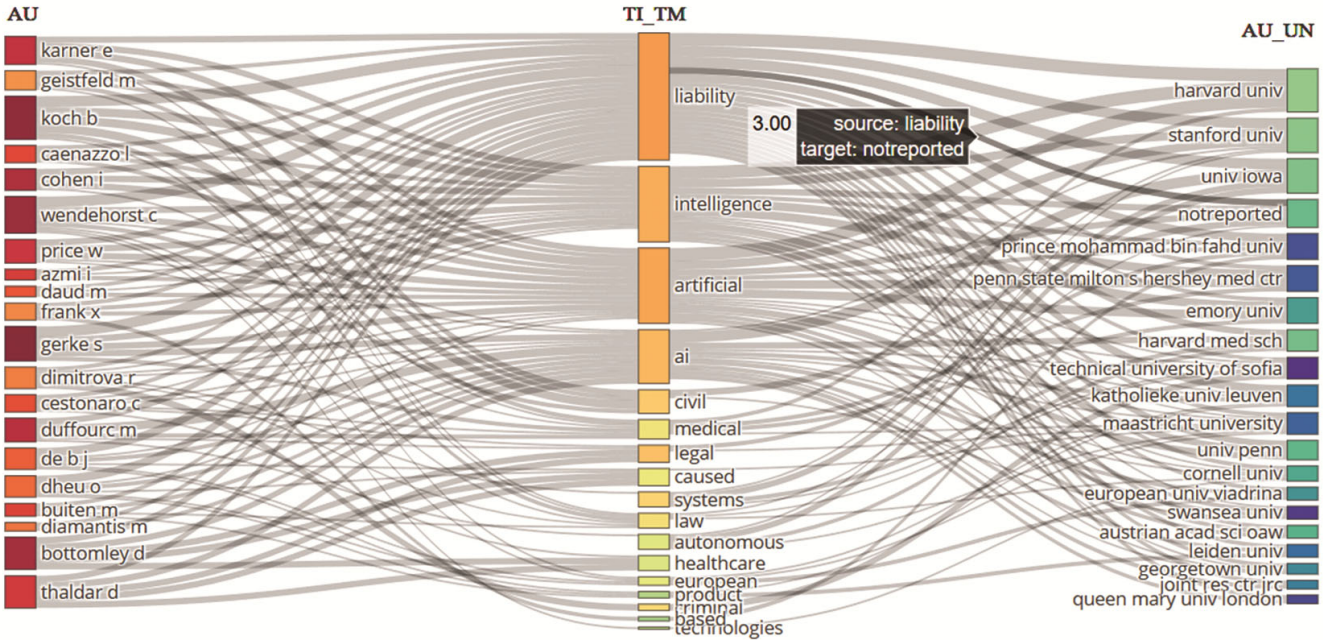

Fig. 6 — Sankey Diagram

The Authors of the AI liability article was mainly from Harvard University, the university produced the highest number of scientific productions with the (Number of Article N=11), (Fig. 9), Pennsylvania State University is in second number with the scientific production of (N=6), followed by Pennsylvania Commonwealths and Stanford University (N=4), Harvard Medical School, the University of Iowa, University of Canterbury (N=3), and Cornell University and Leiden University Excl Lumc (N=2).

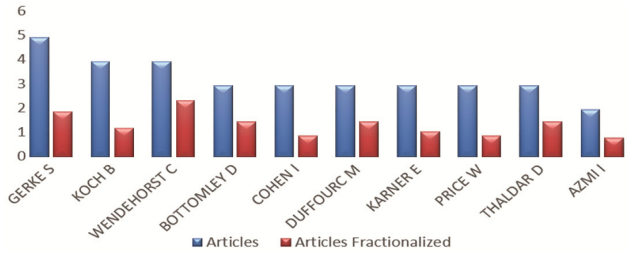

Fig. 8 — Top ten most relevant authors

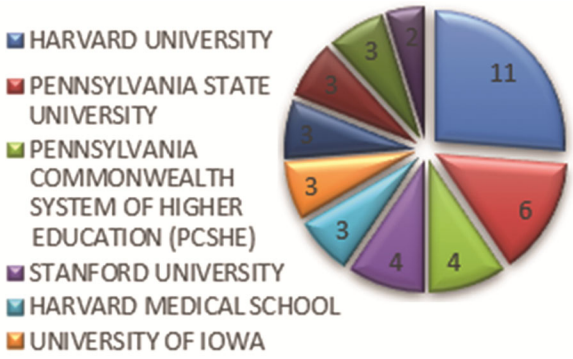

Fig. 9 — Most relevant affiliations

The collaboration among the author network is shown in the fig. 10 This recorded that within the domain of artificial intelligence, legal liability researches the coach B Greek S and Karner E stand out as the central figure in respective of the clusters which indicate their pivotal role in driving the scholarly output and the collaboration network in the artificial intelligence liability domain. While the Gerke s appear to be the center figure which is densely connected to the red cluster and likely focus on the healthcare related liability issues which indicates a tight knit and the thematical focus group Similarly, the coach B also leads a well-defined cluster, either strong interconnections reflecting the consistent collaborative engagement with the other authors Some of the authors, like burrito axe and Kelton, appear as isolated or collected with the minimum nodes, which point out they are more independent and making a research effort on the niche areas.

Similarly, the collaboration among the institutions is shown in Fig. 11. This emphasizes that the Howard University forms the most dominant collaboration hub with the multiple linkage of other research bodies. This reinforced it is status as a leader in the ail legal scholarships Following the Pennsylvania State University which is closely surrounded by a well-structured cluster of the connected institution. Other significant contributors include the University of Oxford, M4 university, with a visual collaborative network However, the authors are from the similar network is found as a collaborative network. This records the need to strengthen international partnership and foster a more integrated global disclosure around the governance and regulation of artificial intelligence

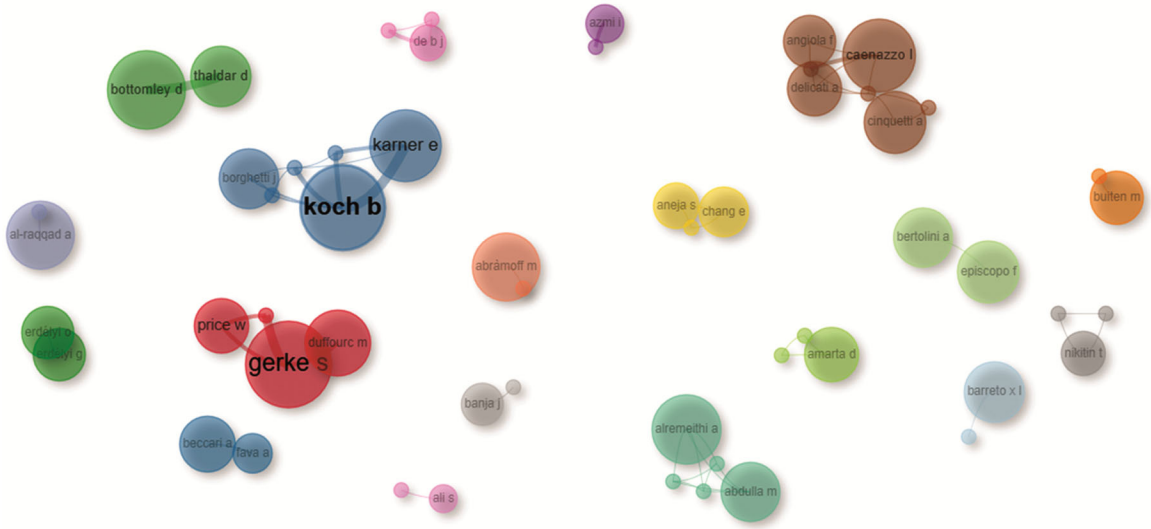

Fig. 10 — Collaboration network of Author

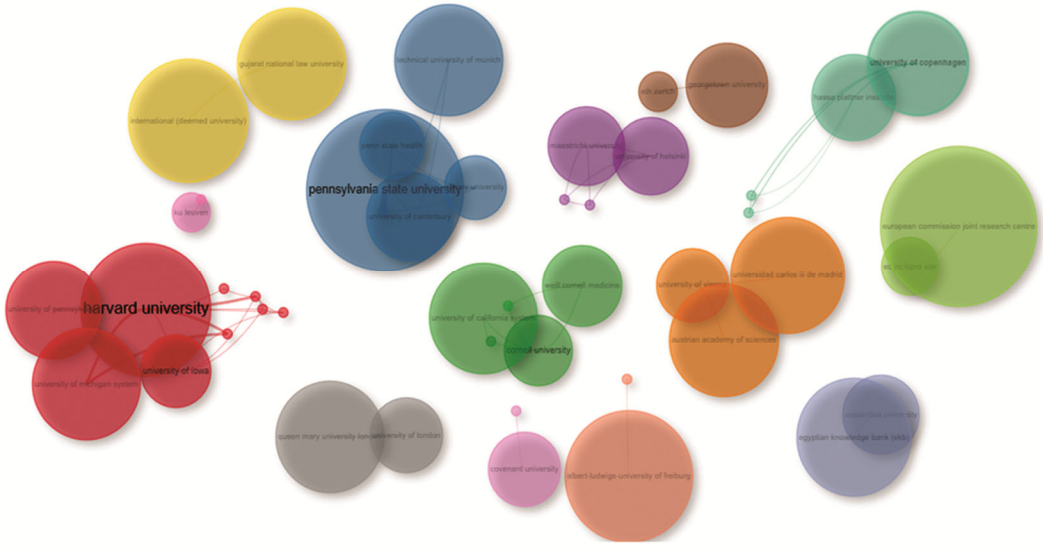

Fig. 11 — Collaboration network of Institution

Table 3 — Countries scientific production

Country	Frequency
USA	71
ITALY	17
UK	13
GERMANY	12
AUSTRIA	11
BELGIUM	8
NETHERLANDS	8
SPAIN	7
BRAZIL	5
PORTUGAL	5

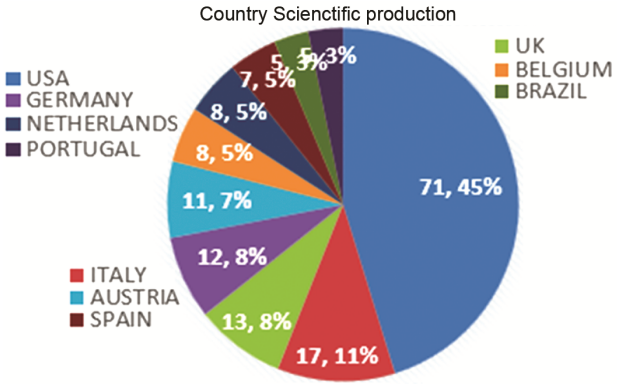

Fig. 12 — Countries scientific production

Top Country and Most Relevant Document

The finding of the top countries working on the artificial intelligence liability and the most relevant documents which provided the different approach on the AI liability issues. The country's scientific production is presented under Table 3 and Fig. 12 Where the USA found as the leading country producing scientific research on AI liability with Freq (N=68), followed by Italy (N=22), Brazil (N=20), Germany (N=19) and UK (N=13).

The findings of the relevant document are shown in Table 4 and Fig. 13, The document by Price W N, Gerke S & Cohen I G (2019). Potential liability for physicians using artificial intelligence found as the most relevant document with N=168 scientific citations and N=425 overall citation.[34]

Followed by Vladeck D C (2014). Machines without principals: liability rules and artificial intelligence with N=108 scientific citation and N=460 overall citation.[35]

Trending Topic Searched in Title, Word Cloud and Co-occurrence Network

This section represents the finding of trend topic searched in title from 2020 to 2024, The word cloud and the co-occurrence network searched in the data.

The Trend topic search in title from 2020 to 2024 is shown in Fig. 14 Where it is obedient that liability artificial intelligence was the most dominant topic in 2020, marked the peak focus on the core subject of ai legal accountability. These foundational terms form the basis for the research and debate around the air regulation, such as EU artificial intelligence act and the liability directive proposals. Year 2023 Shift the noticeable with more applied and domain specific keywords such as healthcare, medicine, medical legal, which gained the prominence importance and indicate the growing interest of academia on the sectoral based liability implication, particularly focusing the healthcare and the biomedical field This shows that

Table 4 — Most relevant document

DOI	Paper	Total Citations	TC per Year	Normalized TC
10.1001/jama.2019.15064	PRICE WN, 2019, JAMA-J AM MED ASSOC	168	24.00	4.80
https://digitalcommons.law.uw.edu/wlr/vol89/iss1/6	VLADECK DC, 2014, WASH LAW REV	108	9.00	1.00
10.1001/amajethics.2019.160	SULLIVAN HR, 2019, AMA J ETHICS	91	13.00	2.60
10.1016/j.clsr.2015.03.008	CERKA P, 2015, COMPUT LAW SECUR REV	60	5.45	1.26
10.1007/s00146-020-01019-6	SMITH H, 2021, AI SOC	42	8.40	4.71
10.1007/978-3-319-10124-8	HALLEVY G, 2015, LIABIL FOR CRIMES INVOLVING ARTIFICIAL INTELLIGENCE SYSTEMS	35	3.18	0.74
10.2967/jnumed.120.256032	TOBIA K, 2021, J NUCL MED	29	5.80	3.25
10.1111/1468-0009.12504	MALIHA G, 2021, MILBANK Q	26	5.20	2.91
NA	GIUFFRIDA I, 2019, FORDHAM LAW REV	26	3.71	0.74
10.1177/0968533220945766	SMITH H, 2020, MED LAW INT	26	4.33	4.42

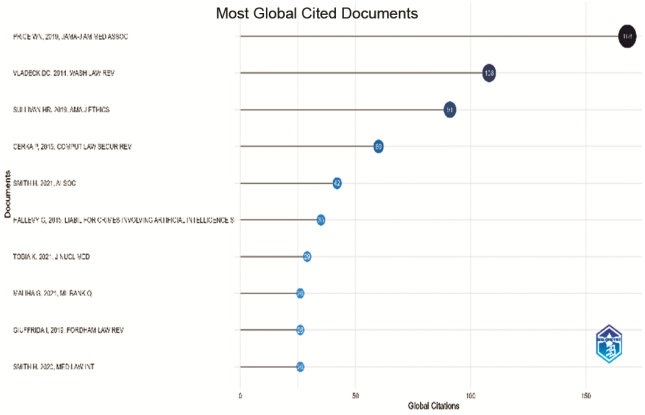

Fig. 13 — Most relevant document

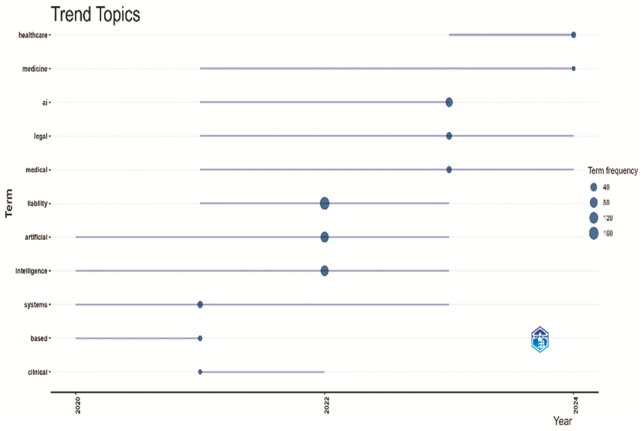

Fig. 14 — Trend topic

the trend in the researchers now moving from the beyond legal concern to explore how the ai impact the professional responsibility in the clinical and legal practices, Further, the word clinical system and based appear from 2020 and 2021 represent that the

Fig. 15 — Words cloud of the most frequently used keyword Searched in abstract in AI liability research

technological are deeply related on the discussion focusing on the system architecture and the clinical integration of AI.

The word cloud is shown in Fig. 15 which represent the most frequently keywords used in AI liability research search from Abstract. In the core of the cloud, the term liability is the most dominant term, which reflect the central concern of the research, how the responsibility and accountability are assigned in a driven involvement. The surrounding terms, such as artificial intelligence, legal and system, appears the prominent and emphasized the legal technical interface that frames the most academic disclosure in this area. Further, the inclusion of the words like autonomous medical products, civil criminals suggest that the particular attention has been given to the sector specific liability issues, especially concerning the health care and product safety and autonomous vehicles. Additionally, the words such as directive framework, regulation and rules point out, thus regulatory and

policy-oriented focus in the literature especially in relation to the emerging legislative instruments like the European Union artificial intelligence, are and the national ai government's framework of various countries. The notable word such as human responsibility and damage also reflects the ethical concern and the impact of artificial intelligence on the rights of the individual which further reinforcing the strong intersection of law ethics and technology the less prominent, but still visible terms, such as criminal right and risk, indicate the unexplored, but emerging areas of the academic interest.

The co-occurrence network surged in the title is shown in Fig. 16 This visualize the keyword co-occurrence network of the most frequent used term in the academic literature related to the artificial intelligence and liability Each node represents the keyword connected with each other on the basis of frequency and appearance. The line connecting the nodes illustrate that the co-occurrence strength between the keywords, how often they have appeared together in the same article, and the color of the different colors show the related keywords suggesting common research subfield, The liability and intelligence at the center dominate both the size and the connectivity. Their central position represents the core concept around the literature, which is closely related to the terms such as responsibility, ethics,

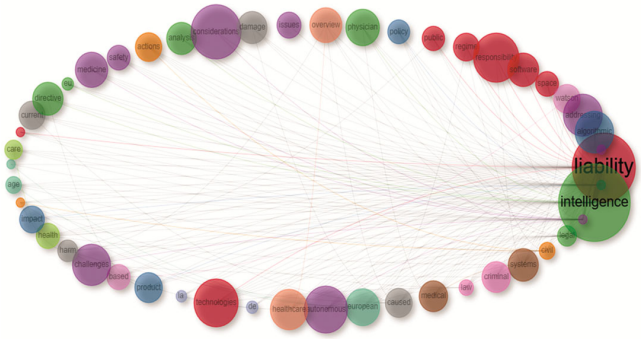

Fig. 16 — Co-occurrence network in title

autonomous regulation, which shows the legal and ethical issues in ai governance and the prominently include the responsibility and accountability. Another notable cluster includes the keywords such as the health care, medical diagnose physician, which indicates that the significant volume of research is dealing with the ai liability in healthcare setting Still no particular focus is being made on the governing frameworks of issues

1.1 Thematic and Factorial Analysis and Document Coupling

This section represents the finding of thematic map, factorial analysis and the document coupling searched on the artificial intelligence and liability area.

The thematic map is represented in Table 5 and Fig. 17. The finding of the thematic map represents the structure and development of research topic within the field of artificial intelligence and liability. The horizontal axis represents the Callon Centrality Which represent the thematic relevance and the connectivity of keyword within the broad research landscape The vertical axis or Callon density represent the internal cohesive and well-developed Theme within its niche. The parameter divided into the two category and 4 quadrants Motor theme, basic theme, niche theme and emerging or declining themes. In the basic theme, it is found that the foundational topics, such as liability, artificial intelligence, legal and health care, are the high relevancy and connected across the literature to form the backbone of the field. However, their relatability is low density that suggests, while these topics are processor, the internally scholarly cohesions within these themes is still evolving the term liability standouts as the most central concept with the high centrality of 6.499 and the fee frequency of 396 mentions.

The motor theme connects both the high centrality nodes and the highly developed topics where it was found that medical clinical, technological law and

Table 5 — Thematic map Cluster data

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
Liability	6.499	44.923	51	16	396
AI	1.203	67.697	43	46	64
Civil	4.514	37.024	49	13	45
Systems	0.757	5.882	33	1	17
Criminal	1.081	23.077	39	4	16
Law	5.235	51.797	50	36	49
Medical	6.499	79.887	52	49	64
Healthcare	1.147	49.074	41	17	13
Product	1.479	36.875	46	12	18
Based	1.533	193.519	47	52	24

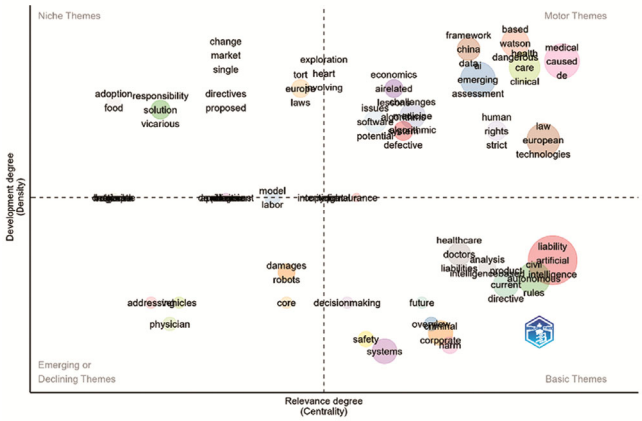

Fig. 17 —Thematic map

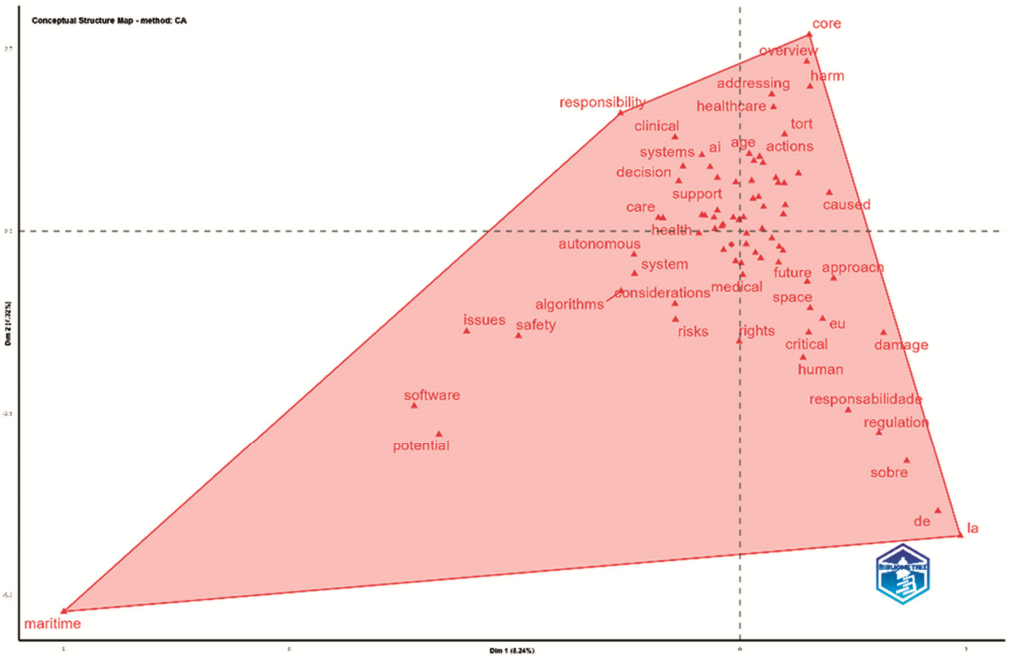

Fig. 18 — Factorial analysis search in title

human rights are the most related topics and form the intersection of legal and health care consideration within the ai research. The niche theme includes the words such as vicarious liability taught market food responsibility and the solution. These themes may evolve into the mortar themes with the increased scholarly attention and broader interdisciplinary attention with the integration of artificial intelligence liability in various sectors such as marketing, food and solutions or consultancies. At the end, the emerging or declining theme include the terms like robot decision making, vehicles, damages and physicians These areas are currently lacking in these strong thematic cohesions and widespread relevancy which gave them the future exploration and the emerging area for instance, the legal and ethical questions surrounding the autonomous vehicle and robotic decision making are still evolving and may gain the prominence as this technology are more widely developed and emerging.

The correspondence factorial analysis is presented in Fig. 18; this offers a detailed visualization of thematic organization within the filed of AI. The core cluster store the emerging areas such as AI, clinical, system, healthcare, decision support, autonomous medical and risk. These keywords indicate that the literature is strongly focused on the intersection of AI and clinical decision, which makes it very particular with the

Table 6 — Coupling of network cluster detail

Label	Group	Freq	Centrality	Impact
liability - conf 10.4% ai - conf 83.3% legal - conf 35%	1	11	0.604	1.018
liability - conf 89.6% artificial - conf 100% intelligence - conf 100%	2	89	1.049	1.31

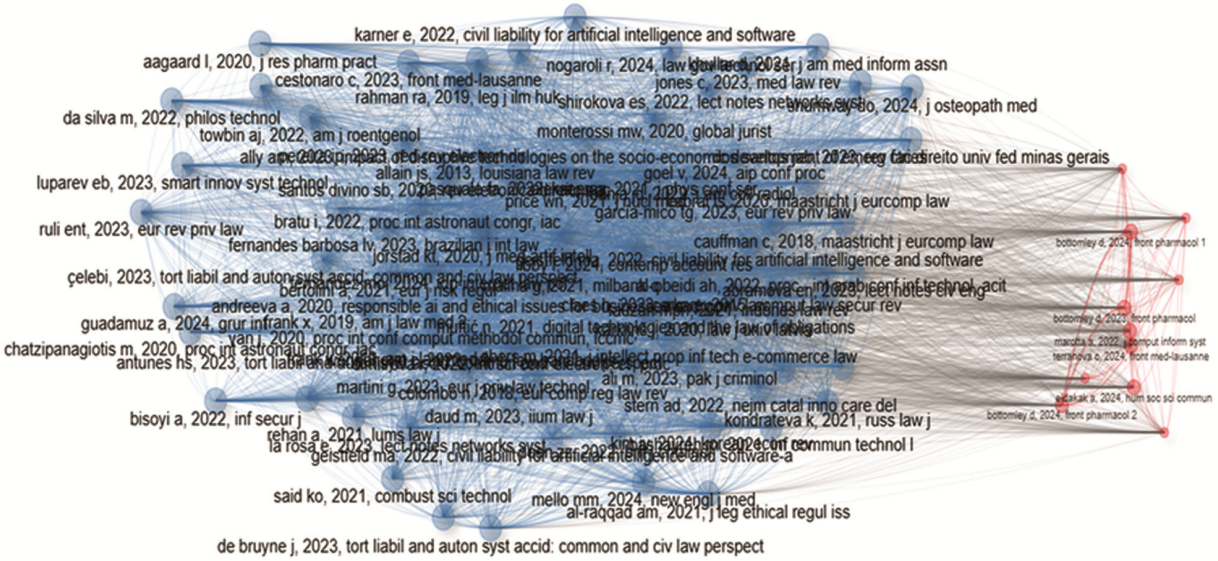

Fig. 19 — Coupling network found in title

healthcare environment. These themes represent that the intellectual core of the field reflecting a mature and cohesive research, which addressing the legal, ethical and operational risk posed by the autonomous medical system and artificial intelligence support healthcare delivery system. Further, the several peripheral cluster highlight that there are underdeveloped areas such as maritime software, potential, which suggests to the exploratory research into the ai application beyond the health care. The maritime navigation and sift software specific liability appears less integrated into the mainstream discussions The terms like harm damage, EU, regulation, critical and human rights, also reflect the ongoing policies and governance discussion around this topic.

The document co citation clustering network presented in the Table 6 and Fig. 19. This presents the finding of research landscape and intellectual landscape of artificial intelligence and legal liability scholarships. By clustering the publication based on how frequently they cited each other the two primary thematic cluster emerged from the analysis. The larger cluster in the blue represent a broad and interdisciplinary body of literature, focused on the topics such as artificial intelligence, liability, health care, legal responsibility, taught law and the ethical consideration where the Karner (2022), de Bruyne (2023), and Da Silva (2022) The form the foundational role in this text, playing a shape in the academic dialogues on the civil and taught liability. The second close tour in red shows the smaller terms, whether the author diversity, but highly concentrated This colour focus on the comparative legal analysis, particularly the differences between the common law and civil law approach to the ai and autonomous system. With the high centrality score, 1.049 and the impact value of 1.31. This cluster represents the strong thematic cohesions and influence in the research community. It contains the core theme such as liability, artificial and intelligence The central reference point from the scholar point of view provide that the legal theory and al liability jurisprudence are emerging.

Conclusion and Discussion

The Overall finding of the Bibliometric study of AI liability from Timespan 2011-2024 provide the comprehensive insights and scholarly discourse around one of the most complex legal challenges of technological era. The annual growth for this area recorded as 26.48% where the data confirms a significant and accelerating response to the legal and ethical uncertainties and issue posed by the autonomous intelligence system. The USA found as the leading country working towards the liability approach with

the collaboration of different region. This reflect that the global prelease creation of AI applications across various sectors, such as autonomous transport, the digital governance, healthcare industry which required the risk assessment to minimize the harm, better regulation and clear responsibility directive.

The findings from the thematic and conceptual mappings reveals that the healthcare sector has immersed as the epicenter of artificial intelligent liability discourse. The visualization of the keyword co-occurrence network and conceptual structure map place the healthcare clinical, medical and systems at the core of the discussion among the literature. This reflects not only the rising deployment of artificial intelligence and diagnostic and treatment planning but it also poses the critical risks associated with the black box nature of artificial intelligence system The interpreted AI generated diseases especially in clinical settings, where the misdiagnose can lead to the irreversible harm and damages, presents a formidable barrier to assigning the legal liability due to the involvement of various stakeholders. The strategic thematic map also clarifies that these issues are under the motor theme and the basic theme which highlight the foundational and forward driving role in the literature.

Other findings reflect that the autonomous navigation, particularly in the context of self driving, vehicles and maritime ai reflected as the core in the conceptual map. The terms like autonomous safety algorithm, decision making remain under developed, yet centrally related, and indicating both have the potential for growth and the current complexity of unresolved legal framework. The trend analysis chart also clears the steady rise in the focus of legal and regulatory terms Post 2022 which give the concern for how liability should be allocated in case of accident involving through the autonomous agent or autonomous vehicles.

From the point of the regulation and policy, the analysis of legislative and jurisdictional trend is supported by the various cluster and thematic densities This recorded as the European Union leading regulatory innovation with initiatives such as ai liability directives and their revised product liability directives. However, the course iteration and thematic positioning of the legal keywords, such as laws, rules, rights and regulation, suggest that there is a gap in the technological advancement and the legal responses This institution between the assistive and the full autonomous system, especially referring to the health care and mobilities is legislative instrument rather than a one size fit of all liability approach and it also lacks exhaustive liability approach.

The global collaboration network from the international author and affiliation, underscores the universal nature of ai liability concern. This present that the jurisdiction, such as United States, Germany and Netherland, needs harmonized global framework, especially in the areas like product liability, cross border ai deployment and the forensics application of artificial intelligence The increasingly use of ai find in the legal context also include the source of evidence in the civil and criminal trials which record the urgency to develop adaptive and anticipatory jurisprudential model and the framework towards the liability approach Interestingly, the emerging in niche theme such as maritime AI. software, accountability and robot autonomy reflect the conceptual and strategic mapping, which are peripheral, but gaining academic interest.

The overall analysis shows that there is a necessity for the comprehensive and adaptive legal framework With the pace of rapid advancement in AI technologies, The current state of ai liability research also revealed that robust foundational development and critical gaps particularly integrating the technological innovation with the legal accountability and responsibility The center legal medical in the literature emerge as the opportunity as well as the challenge Other emerging opportunities are in maritime criminal and cross jurisdictional ai liability to ensure all these promise of AI and the public safety the protection are required. There is a pricing need for the international disciplinary collaboration research among the legal scholar, technologist and the policy maker. To develop this strong approach and create the framework which ensures the trustworthiness of ai and the accountability in case of failure, while for sure the innovation.

The future research must ensure the development of sector specific liability models, such as medical versus the autonomous vehicles, liability models to give the better understanding around the ai liability The jurisprudence volition to address the opaque decision making and the clear understanding of liability in artificial intelligence is also required. The strong systematic analysis is also required to understand the various approach of Liability in case of using Software and how it's different from Tradition Programme and emerging autonomous Programme system.

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