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Artificial Intelligence and Regional Health Vulnerabilities: A Bibliometric Review of Global Trends in Non-Communicable Disease Research

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Abstract

Non-communicable diseases (NCDs), including cardiovascular disease, diabetes, cancer, and chronic respiratory conditions, are the leading causes of death worldwide. These diseases are driven by socioeconomic disparities, unhealthy lifestyles, and environmental factors. AI can improve NCD vulnerability mapping through the use of big data and risk prediction, but faces data and access barriers in developing countries. This study explores how AI can be leveraged to more effectively map regional NCD vulnerability. This study seeks to analyze global research trends in the application of Artificial Intelligence (AI) to map regional vulnerability to non-communicable diseases (NCDs). This study uses a bibliometric analysis of Scopus-indexed, peer-reviewed articles (2006–2025) on AI and NCD vulnerability, processed with Excel and VOSviewer. A total of 3,626 articles were analyzed, showing a sharp rise in AI–NCD research since 2007, peaking in 2024 with 723 publications and 35,148 citations. Frequent keywords included "machine learning", "COVID-19", "mental health", "diabetes", and "artificial intelligence". The field is marked by strong international collaboration, led by the US, China, and the UK, with over 96% of studies involving multi-country co-authorship. AI shows strong potential for mapping regional NCD vulnerability, improving early detection, and enhancing predictive risk assessment to strengthen national health policies.

INTRODUCTION

Non-communicable diseases (NCDs), such as cardiovascular disease, diabetes, cancer, and chronic respiratory conditions, have become the leading cause of death worldwide. According to data from the World Health Organization (WHO), NCDs are responsible for nearly 74% of all global deaths, which highlights their profound impact on public health (WHO, 2023). In Indonesia, the growing prevalence of NCDs, driven by lifestyle changes, rapid urbanization, and environmental factors, has intensified the public health crisis and demands urgent attention (Kemenkes, 2019). The consequences of NCDs extend beyond mortality rates, and this places significant economic burdens on healthcare systems and severely impairing the population quality of life (Peng et al., 2024).

A major challenge in controlling NCDs lies in addressing regional vulnerability. Regional vulnerability to NCDs is shaped by a complex interplay of socioeconomic status, lifestyle behaviors, environmental exposures, and access to quality healthcare services (St-Pierre et al., 2023). However, traditional approaches to identifying high-risk areas remain inadequate. These met-

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hods often rely on incomplete or non-integrated data and employ macro-level analyses that fail to consider localized determinants of vulnerability. This creates a substantial gap in effective NCD management, as highly vulnerable areas may be overlooked by health authorities and remain underserved (Pati et al., 2020; Torabi et al., 2025).

Conventional healthcare systems frequently struggle to prioritize regions most in need of intervention. Without a clear understanding of the geographic distribution of vulnerability, health policies and programs are unlikely to achieve optimal impact. Hence, advanced data-driven approaches are urgently needed to provide deeper and more targeted insights into regional NCD vulnerability (Samuel Adelusi et al., 2024).

In recent years, artificial intelligence (AI) has emerged as a powerful tool for addressing these challenges. AI's ability to process and analyze vast amounts of data, including health, social, economic, and environmental information, allows it to uncover hidden patterns and deliver more accurate predictions than traditional methods. Numerous studies have documented AI's contributions to healthcare, ranging from early disease detection to efficient risk stratification. For instance, AI has been used to analyze mammographic images for breast cancer detection through convolutional neural networks (CNNs), achieving accuracy rates above 90% (Al-Karawi et al., 2024; Nurbaiti et al., 2024; Wang, 2024). In the context of cardiovascular disease, machine learning techniques have been employed to predict heart attack risk based on patient medical history and known risk factors, enabling earlier interventions (B. Marqas et al., 2023; Ogunpola et al., 2024). AI has also demonstrated success in diagnosing Alzheimer's disease using deep learning algorithms to interpret brain MRI images, aiding in distinguishing early-stage Alzheimer's from other conditions, such as mild cognitive impairment (Mohsen, 2025; Saleem et al., 2022; Yao et al., 2023). Furthermore, AI has been applied to diabetes care, where predictive modeling techniques have been used to identify patients at risk of developing complications such as diabetic retinopathy long before clinical symptoms appear (Huang et al., 2023; Kalavar et al., 2020).

Despite technological advancements, applying AI to the early detection and risk assessment of regional noncommunicable disease (NCD) vulnerability continues to face several obstacles. Data quality inconsistencies, limited access to advanced technologies in developing countries, and socio-economic disparities that influence disease vulnerability are major barriers to AI implementation (Bernardi et al., 2023). In addition, concerns about data privacy and algorithmic bias present serious risks; inaccurate or non-representative algorithms may lead to flawed predictions and ultimately compromise data-driven decision-making (Hanna et al., 2025).

Currently, there is a critical gap in the literature regarding the limited number of studies that examine regional vulnerability to noncommunicable diseases (NCDs) using artificial intelligence (AI) technologies. Additionally, only few studies explore how cross-sectoral collaboration could improve the deployment of AI at the regional level. While much of the current research focuses on individual-level disease detection, there is a pressing need to investigate how AI can be leveraged to map vulnerability at the community or regional scale.

This study aims to address this gap by offering a thorough analysis of how AI can be used to map regional vulnerability to noncommunicable diseases (NCDs), while also examining the challenges and opportunities of AI implementation in Indonesia. Through bibliometric analysis and a review of related literature, the study aims to identify global trends in AI-driven NCD management, assess its practical applications in vulnerable regions, and propose strategies to optimize the integration of AI into regional health policymaking.

METHODS

This research conducted an extensive bibliometric analysis to capture a comprehensive understanding of scholarly trends concerning regional vulnerability to non-communicable diseases (NCDs), with particular emphasis on the integration of Artificial Intelligence (AI). As a quantitative technique, bibliometric analysis facilitates the evaluation and visualization of scientific output within a defined research domain. In this context, it was chosen to ensure efficient yet rigorous analysis, maintaining both the depth and reliability of the study's outcomes. This methodological approach allowed for the systematic identification of publication dynamics, patterns of international collaboration, predominant thematic directions, and emerging areas of inquiry associated with AI applications in NCD prevention and control. Additionally, it supported the mapping of knowledge structures, which highlights influential publications, key authors, and notable gaps within the existing literature. To streamline the interpretive process, a narrative synthesis was adopted in place of a purely quantitative synthesis, which was expected to enable a focused yet analytically rich presentation of the evidence base.

In contrast to systematic reviews that typically draw from multiple bibliographic databases, this study intentionally confined its literature search to a single, comprehensive source. All relevant publications were retrieved exclusively from the Scopus database (www.scopus.com), a globally recognized repository of peer-reviewed scientific literature spanning diverse academic disciplines. Scopus was selected due to its extensive interdisciplinary scope and its robust, well-curated metadata, which offers detailed information on citation metrics, authorship, institutional affiliations, and country-level contributions. Relying on Scopus provided consistent access to high-quality, current literature directly aligned with the study's thematic focus.

To ensure comprehensive and relevant data collection, the following search terms were used: *("vulnerable" OR "vulnerability" OR "health vulnerability" OR "population vulnerability" OR "community vulnerability" OR "regional vulnerability") AND ("non communicable disease" OR "NCD" OR "chronic disease") AND ("machine learning" OR "artificial intelligence" OR "ML" OR "AI" OR "deep learning" OR "neural networks" OR "cognitive computing" OR "natural language processing" OR "expert systems" OR "computer vision" OR "autonomous systems" OR "robotic intelligence" OR "computational intelligence" OR "AI algorithms" OR "intelligent systems" OR "AI technologies" OR "automated intelligence" OR "smart systems" OR "self-learning systems" OR "AI applications" OR "cognitive machines" OR "machine intelligence" OR "data-driven intelligence" OR "algorithmic intelligence" OR "automated decision-making" OR "intelligent automation" OR "AI models" OR "AI frameworks" OR "cognitive algorithms" OR "learning algorithms" OR "AI-driven systems" OR "intelligent agents" OR "AI-driven analytics") AND (PUBYEAR > 2006 AND PUBYEAR < 2026)*

These keywords were carefully designed to ensure a broad and inclusive search, encompassing diverse terms relevant to regional vulnerability, non-communicable diseases, and AI-based risk assessment. This search strategy ensures that all pertinent studies within the scope of this research topic are captured.

To ensure a systematic and methodologically sound selection process, clearly defined inclusion and exclusion criteria were applied. The inclusion parameters were developed to capture scientifically valid and high-impact research directly relevant to the study's thematic focus. Specifically, the analysis encompassed articles published between 2006 and 2025, a period that reflects recent advancements in the application of artificial intelligence (AI) for detecting and assessing the risk of non-communicable diseases (NCDs). Only English-language publications were considered, in order to maintain international accessibility and alignment with the expectations of high-impact academic journals. The scope was further narrowed to include only primary research articles published in peer-reviewed journals, as these works offer original empirical findings that are essential to the objectives of bibliometric evaluation.

Publications that did not meet these criteria were systematically excluded. The exclusion process ruled out non-primary sources such as review articles, monographs, book chapters, conference abstracts and proceedings, editorials, brief reports, letters to the editor, retracted papers, data articles, and conference reviews, as these types of literature do not typically contribute original data. Additionally, studies that lacked relevance to regional NCD vulnerability or did not involve the application of AI within a health-related context were omitted. The implementation of these criteria ensured the inclusion of only robust, thematically relevant, and data-driven research, thereby enhancing the overall validity and scholarly utility of the study's findings.

This study used Microsoft Excel and VOSviewer to perform a bibliometric analysis and visualize the research. Excel was used to organize key indicators, such as publication trends, citation metrics, and author contributions. VOSviewer, on the other hand, enabled a deeper analysis of keywords, collaboration networks, and institutional linkages using Scopus data.

Through co-occurrence analysis, VOSviewer identified major research hotspots and thematic clusters, particularly in the early detection and risk stratification of noncommunicable diseases (NCDs). VOSviewer also visualized collaboration patterns and global research structures. Its clustering and mapping features highlighted key themes, emerging trends, and under-explored areas in AI-driven NCD research.

RESULTS AND DISCUSSION

A systematic literature search of studies published between 2006 and 2025 identified 6,892 relevant articles using predefined search terms. The considerable number of publications highlights a surge in research focus on the integration of artificial intelligence (AI) into non-communicable disease (NCD) management, specifically in AI-driven risk prediction and diagnostic technologies. The retrieved literature comprised diverse publication formats, spanning interdisciplinary contributions from healthcare and AI fields.

To ensure dataset accuracy, we implemented a rigorous exclusion process to remove studies that failed to meet the inclusion criteria because of mismatched publication types, language barriers, or irrelevance to the study's core focus. After screening, 3,626 articles remained eligible for bibliometric analysis.

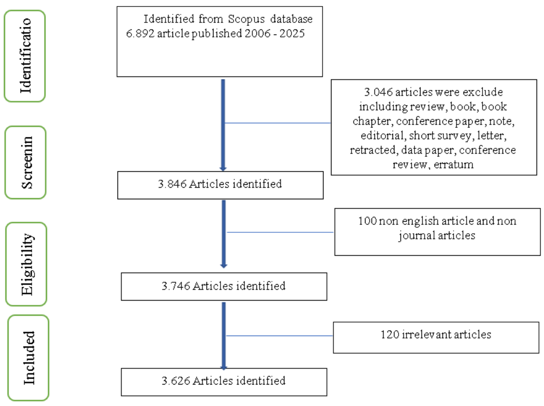

Figure 1. Flow Chart Literature Search and Screening

The bibliometric analysis reveals substantial scholarly impact, with publications in this field collectively amassing 176,246 citations, averaging 48.61 citations per article. This robust citation performance demonstrates that AI applications in non-communicable disease (NCD) research have achieved both significant scientific relevance and considerable influence on advancing knowledge in public health and technology sectors.

The bibliometric analysis shows a significant academic impact across key quantitative indicators. The H-index (97) and G-index (98) reflect high productivity and significant citation influence in artificial intelligence (AI) research on non-communicable diseases (NCDs). On average, 3,584 publications receive 49.18 citations, confirming their role as core references. Collaboration is prevalent, with 96.7% of works produced by teams and only 3.3% by individuals, highlighting strong interdisciplinarity. This is supported by 27,219 unique authors, averaging 9.67 per paper. International collaboration accounts for 96.75% of publications, emphasizing the importance of global cooperation in advancing AI-based health solutions. The collaboration index (7.62) and coefficient (0.97) further confirm the field's capacity for sustained, productive research collaboration.

Table 1. Main Bibliometric Indicator

Indicator	Value
Productivity	
Total Publications	3626
Active Years	19
Productivity per Year	190,84
Annual Growth Rate (%)	4245,45
Impact	
Total Citations	176246
Average Citations per Publication	48,61
Number of Cited Publications	3584
Citations per Cited Publication	49,18
H-index	97
G-index	98
Authorship	
Coauthored Publications	3508
Sole-authored Publications	118
Number of Contributing Authors	27219
Authors of Sole-authored Publications	115
Coauthors per Publication	9,67
Collaboration	
Annual Collaboration Index	7,62
Collaboration Index	9,67
Collaboration Coefficient	0,97
International Coauthorships (%)	96,75

A bibliometric analysis reveals a significant increase in research examining regional non-communicable disease (NCD) vulnerability using artificial intelligence (AI) methodologies from 2007 to 2024. Publication output grew remarkably, escalating from 11 articles in 2007 to 723 articles in 2024 (a 65.7-fold increase), reflecting intensifying scholarly interest and rapid conceptual and technological advancements in this interdisciplinary field. This substantial expansion signifies the evolution of AI-driven NCD research from an emerging specialty to a prominent focus within global health scholarship.

Correspondingly, citation metrics exhibited exponential growth, increasing from 422 in 2007 to 35,148 in 2024 (83.3-fold growth). This parallel trajectory in citation impact underscores the field's growing academic influence and practical relevance for both researchers and healthcare professionals. The compounded growth in both publication volume and citation frequency demonstrates widespread recognition of AI's transformative potential in addressing geographically variable NCD patterns and vulnerabilities.

Table 2. Trends in Publications and Citations from 2007 to 2025

Year	Total Publications	Total Citations
2007	11	422
2008	22	1101
2009	18	837
2010	30	1592
2011	28	1263
2012	26	1342
2013	37	1864
2014	43	2179
2015	55	2540
2016	60	2782
2017	85	4114
2018	106	5478
2019	157	7531
2020	244	11506
2021	408	19201
2022	519	25450
2023	576	28630
2024	723	35148
2025	478	23266
2007	11	422
2008	22	1101
2009	18	837
2010	30	1592
2011	28	1263
2012	26	1342
2013	37	1864
2014	43	2179
2015	55	2540
2016	60	2782
2017	85	4114
2018	106	5478
2019	157	7531
2020	244	11506
2021	408	19201
2022	519	25450
2023	576	28630
2024	723	35148
2025	478	23266

The longitudinal analysis reveals distinct phases in the development of AI applications for NCD management research. The foundational period (2007-2016) was characterized by modest scholarly output, with both publication and citation volumes remaining at relatively low levels. A notable transition occurred in 2017, when annual publications reached 85 (compared to ≤20 in previous years) and citations surged to 4,114, signaling the field's emergence as a growing research priority.

The year 2020 marked a critical inflection point, with output jumping to 244 publications and 11,506 citations - increases of 187% and 180% respectively from 2017 levels. This acceleration coincided with the COVID-19 pandemic, suggesting heightened recognition of technology-driven health solutions during global health crises. The subsequent biennium (2021-2022) witnessed unprecedented growth, with annual publications climbing to 408 and 519, while 2022 citations exceeded 25,000. These trajectories demonstrate the field's remarkable maturation from niche specialty to mainstream research domain within both public health and computer science disciplines.

Although the number of publications in 2025 remained high at 478, the number of citations declined to 23,266. This decline is likely due to the time it takes for new articles to gain visibility, as well as a shift toward more specialized topics with narrower audiences. This trend suggests that the field is maturing, moving from rapid expansion to more focused and in-depth research.

Globally, research productivity remains uneven. The United States led with 1,323 publications, followed by China (630), the United Kingdom (352), Canada (259), and Australia (219). While high-income countries still dominate, rising contributions from emerging economies, especially China, indicate a gradual shift toward a more globally distributed research landscape in AI and NCD management.

The average publication year for leading countries indicates a tendency to publish more recent research, with the United States and China showing average publication years between 2020 and 2022. This suggests a high level of active engagement by these countries in the latest developments within the field. In terms of research quality, while high-output countries such as the United States and China dominate in volume, countries with relatively smaller contributions like Brazil and South Korea also demonstrate meaningful

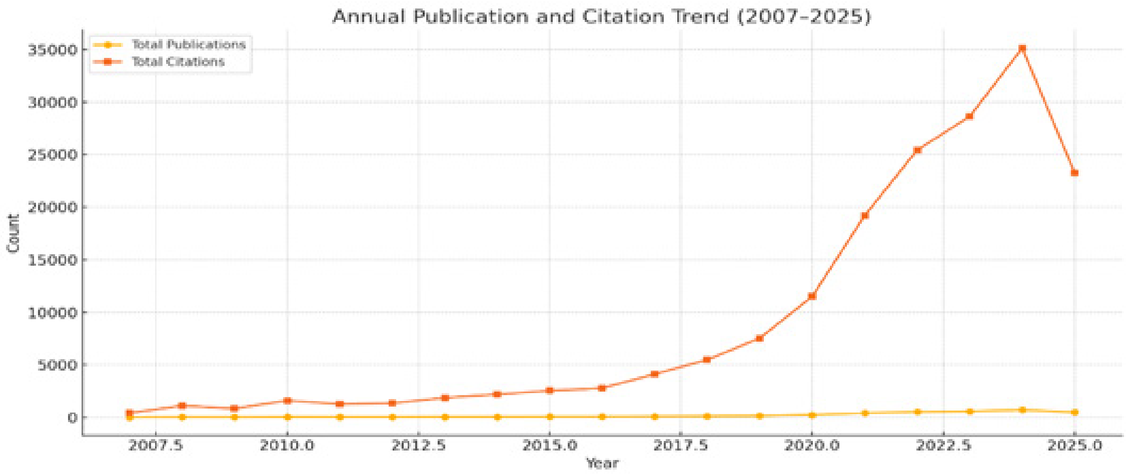

Figure 2. Annual Publication and Citation Trend

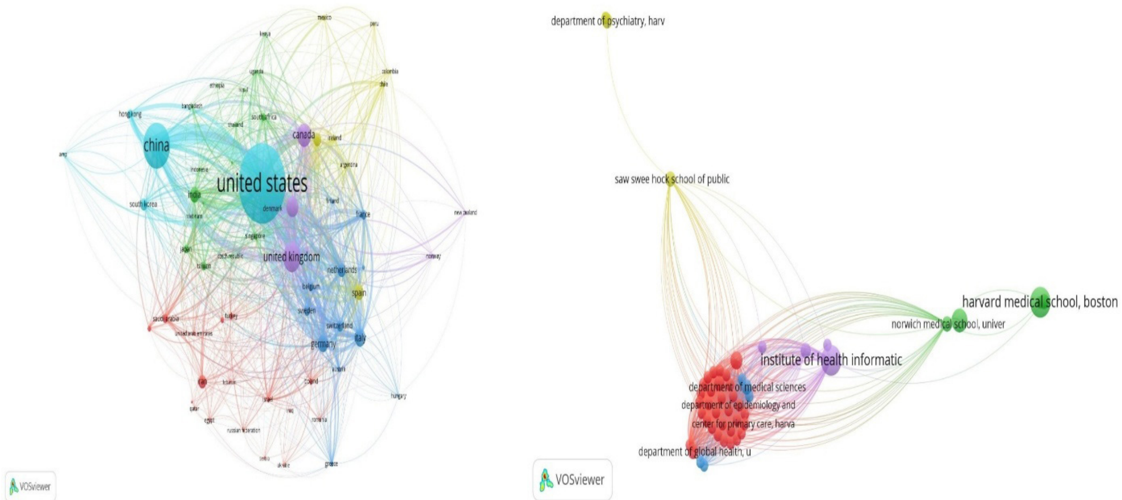

Figure 3. A global collaborative landscape and strategic alliances in AI-NCD scholarship

involvement. Their publications reflect both diversity and extensive collaboration with international partners.

The United States has the most total citations (42,469), followed by the United Kingdom (18,707) and China (14,174). However, the United Kingdom and France have a higher impact per paper, which indicates stronger research quality despite fewer publications. This suggests that, while the United States and China dominate in terms of output quantity, countries like the United Kingdom and France achieve a higher normalized impact per study.

Most contributing countries are recent entrants (2021–2022), which reflects the growing attention to global health issues. International collaboration is extensive, with the United States serving as a central hub, particularly in partnerships with the United Kingdom, China, Canada, Australia, Germany, France, and the Netherlands.

Keyword co-occurrence analysis identifies seven major research clusters in AI and NCDs: 1) COVID-19 and resilience, 2) machine learning and predictive modeling, 3) mental and psychosocial health, 4) clinical risk factors (e.g., diabetes and cardiovascular disease), 5) digital health technologies, 6) social determinants and equity, and 7) general healthcare applications. Together, these clusters highlight the broad, interdisciplinary integration of AI across clinical, technological, and public health domains.

Institution Research Productivity

The bibliometric assessment of institutional contributions identifies the most active and influential research organizations within the examined corpus. At the forefront is the Institute of

Table 3. Bibliometric Analysis of the 20 top Productivity Countries

Country	Total Publications	Total Citations	Normalized Citations	Avg. Publication Year	Avg. Citations
United States	1323	42469	1569,056	2020,951	32,1005
China	630	14174	778,7109	2022,649	22,4984
United Kingdom	352	18707	740,4456	2021,509	53,1449
Canada	259	12903	497,8895	2021,413	49,8185
Australia	219	12070	440,4645	2021,772	55,1142
Italy	184	11647	353,5552	2021,228	63,2989
Germany	175	10496	355,8712	2021,863	59,9771
India	156	6809	334,6825	2022,314	43,6474
Spain	148	11586	346,0908	2021,466	78,2838
Netherlands	131	8466	302,3184	2021,008	64,626
Iran	124	2172	103,6853	2022,54	17,5161
Brazil	121	7936	298,7949	2021,802	65,5868
South Korea	107	5597	193,1607	2021,72	52,3084
Switzerland	96	5513	167,5744	2021,615	57,4271
Sweden	85	6463	140,7037	2021,553	76,0353
France	82	7180	213,9835	2021,012	87,561
Saudi Arabia	72	6003	200,1958	2022,653	83,375
Taiwan	71	1357	55,8093	2021,479	19,1127
Japan	69	6165	192,3879	2020,768	89,3478
Belgium	66	7065	205,1762	2021,106	107,0455
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Saudi Arabia	72	6003	200,1958	2022,653	83,375
Taiwan	71	1357	55,8093	2021,479	19,1127
Japan	69	6165	192,3879	2020,768	89,3478
Belgium	66	7065	205,1762	2021,106	107,0455

Table 4. Strength of Collaboration Countries Study

Source_Country	Target_Country	Strength
United Kingdom	United States	110
China	United States	106
Canada	United States	80
Australia	United States	69
Germany	United States	62
China	United Kingdom	50
Canada	United Kingdom	46
Australia	United Kingdom	45
Netherlands	United States	43
Germany	United Kingdom	43
China	Hong Kong	39
Italy	United States	38
Netherlands	United Kingdom	37
Italy	United Kingdom	36
Australia	China	33
Switzerland	United Kingdom	32
Brazil	United States	32
Spain	United Kingdom	31
Spain	United States	31
Sweden	United States	31

Table 5. Top 10 Institution with the Highest Publications

Institution	Number of Articles	Total Citations	Average Citations
Institute of Health Informatics, University College London, United Kingdom	12	1333	111,08
Harvard Medical School, Boston, United States	11	431	39,18
Nuffield Department of Primary Care Health Sciences, University of Oxford, United Kingdom	8	310	38,75
Department of Medical Social Sciences, Northwestern University, United States	7	33	4,71
Clinical Epidemiology Program, Ottawa Hospital Research Institute, Canada	6	13	2,17
School of Public Health and Preventive Medicine, Monash University, Australia	6	481	80,17
Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia	6	150	25
Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran	6	34	5,67
Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran	6	38	6,33
University of Chinese Academy of Sciences, Beijing, 100049, China	6	461	76,83

Health Informatics at University College London, which authored 12 publications with an exceptional average exceeding 110 citations per article. This indicates the institute's important role in advancing impactful scholarship, particularly in areas such as digital health innovation and epidemiological modeling. Harvard Medical School and the Nuffield Department of Primary Care Health Sciences at the University of Oxford also rank highly, showcasing a strong combination of research productivity and scholarly influence, as reflected by both their total and average citation counts.

High-impact research is concentrated in leading institutions, such as Northwestern University and the Ottawa Hospital Research Institute. These institutions achieve strong citation influence despite publishing fewer papers, which highlights the importance of quality and quantity when evaluating academic performance.

Data indicate that artificial intelligence (AI) and machine learning (ML) are increasingly being applied to noncommunicable disease (NCD) vulnerability, and influential studies have been identified through Scopus based on citation counts. Key works include Bauer et al. (2013), which focuses on dietary protein and has received 1,804 citations. This study is widely used in predictive models. Another influential study is Heidenreich et al. (2022), which focuses on heart failure guidelines and has received 1,550 citations. This study has been integrated into ML-based clinical systems. A third influential study is Popkin et al. (2020), which links obesity to the risk of contracting the SARS-CoV-2 virus in predictive modeling. Additional contributions, such as KDIGO (2020) and Brauer et al. (2024), emphasize the growing role of big data and machine learning (ML) in global health, marking a shift toward precision, data-driven interventions.

Emerging trends from 2023 to 2025 show a rapid growth in topics such as "large language models," "cybersecurity," "loneliness," and "adverse childhood experiences," which indicates new research priorities shaped by digital transformation and post-pandemic challenges.

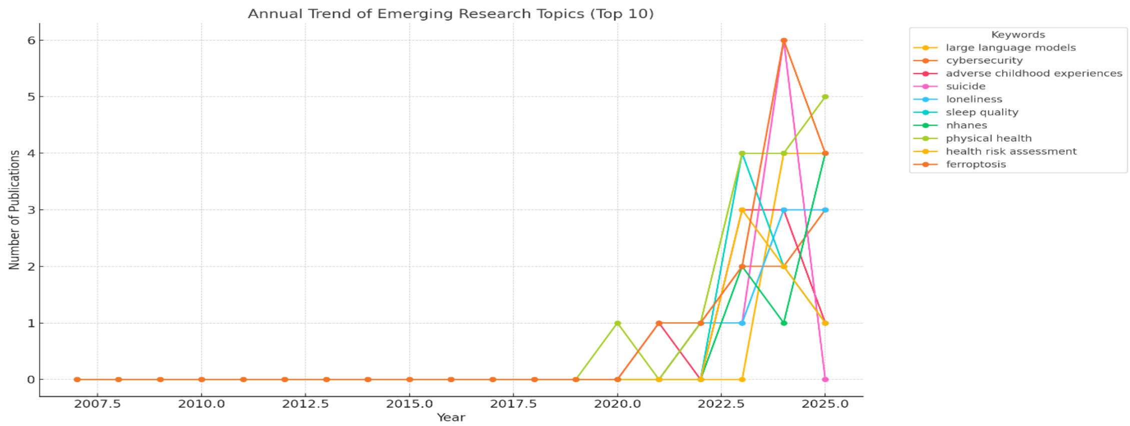

Figure 4. Annual Trend of Emerging Research Topics (Top 10)

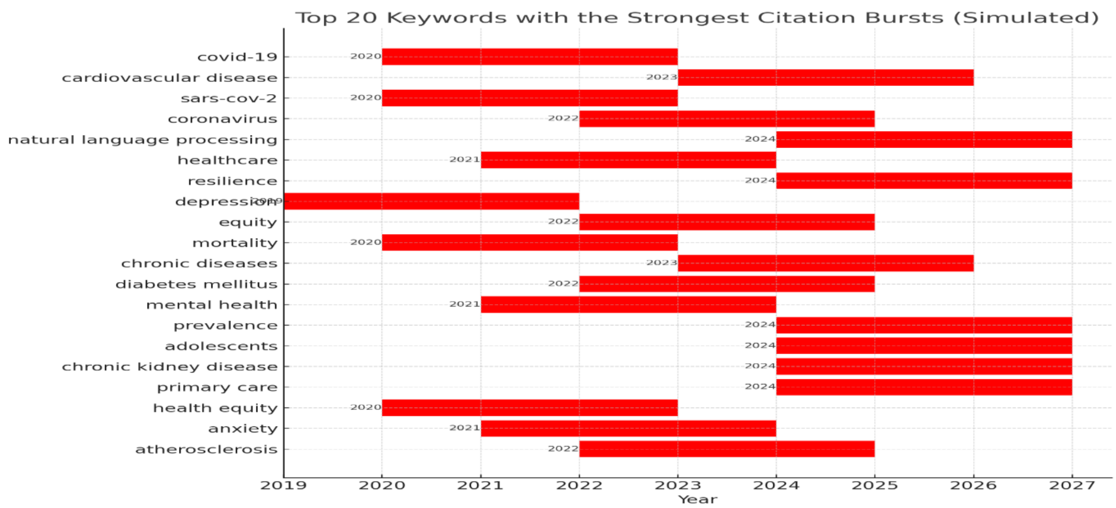

Figure 5. Top 20 Keywords with Strongest Citation Bursts (Simulated)

The visualization of author keyword networks, limited to terms appearing at least 20 times, resulted in the identification of 62 items grouped into 7 thematic clusters. Larger nodes represent the most frequently used keywords, and reflect the primary areas of focus within the field. Nodes in close proximity on the map indicate keywords that are commonly used together, while different colors denote distinct thematic clusters. Thick connecting lines between nodes represent strong semantic relationships.

Keyword analysis revealed several prominent research areas, including *machine learning*, *mental health*, *diabetes*, and *COVID-19*, which serve as strong indicators of current research priorities and the evolving direction of scholarly inquiry in the intersection of AI and non-communicable disease management.

In recent years (2021–2025), there has been a surge in technology-related keywords, such as "natural language processing," "digital health," and "telehealth." This reflects the integration of digital tools in healthcare, particularly after the onset of the pandemic. This trend also signals a shift toward remote care, artificial intelligence (AI) applications, and big data analytics. Citation burst patterns demonstrate how research is increasingly responding to real-world needs driven by the intersection of health challenges, innovation, and equity. This offers key guidance for future investment and collaboration. Overall, the analysis presents the dynamic nature of scientific research, where emerging, high-impact topics align with urgent public health priorities, technological advances, and social determinants of health.

The study also demonstrates the growing strategic role of AI in improving regional vulnerability mapping for noncommunicable diseases (NCDs). Since 2006, there has been significant growth in publications and global collaboration. AI has contributed to early detection, predictive modeling, and evidence-based decision-making. Advances in AI-driven precision medicine enable more targeted and timely healthcare interventions (Subramanian et al., 2020). Over the past two decades, the marked increase in publications, citations, and research impact reflects the global scientific community's growing acknowledgment of AI's potential in strengthening NCD prevention and management strategies (Xiao et al., 2024).

The analysis reveals that high-income countries, notably the United States and the United Kingdom, continue to lead in terms of both research productivity and scholarly influence, largely due to their well-established international collaboration networks. This trend highlights the global dimension of public health challenges and underscores the importance of cross-national and interdisciplinary partnerships in advancing innovation and accelerating the adoption of AI technologies. Importantly, AI-based approaches to early detection have the potential to advance health equity by facilitating timely diagnosis and improving access to care among underserved and marginalized populations (Gurevich et al., 2023). The growing integration of artificial intelligence (AI) into clinical diagnostics, prognostic evaluation, patient management, hospital operations, and community-based healthcare has contributed to greater overall efficiency in health systems (Gnana & Bhavana, 2025; Zuhair et al., 2024). This advancement is particularly beneficial in high-volume care settings and resource-constrained environments, where quality of care is frequently challenged. Although much of the recent research has been driven by nations with advanced technological infrastructure, there has been a marked increase in contributions from low- and middle-income countries, which reflects a more inclusive and globally distributed engagement in the advancement of AI applications in healthcare.

The keyword and topic analysis reveals that research continues to focus heavily on the application of machine learning, deep learning, and other AI algorithms for early detection, risk prediction, and vulnerability assessment related to NCDs. These findings indicate that AI is not only being used for individual-level disease prediction (Maleki Varnosfaderani & Forouzanfar, 2024), but is also increasingly being leveraged to understand vulnerability dynamics at the community and regional levels (Vargas-Santiago et al., 2025). The emergence of new terms such as *"large language models"* and *"cybersecurity"* further suggests that this field is expanding beyond conventional medical applications to include digital and social dimensions of public health. This trend marks an evolution toward more multidisciplinary and adaptive research approaches in response to emerging health challenges.

In recent years, digital health interventions have shown substantial promise in the prevention and management of non-communicable diseases (NCDs). Unlike traditional approaches that often depend on patient self-regulation, digital tools facilitate sustained behavioral change by supporting medication adherence, encouraging self-care, and improving overall compliance (Fitzpatrick, 2023; Lu et al., 2025; Mason et al., 2022). These technologies have proven particularly critical during public health emergencies, such as the CO-

VID-19 pandemic, where they enabled effective management of high-risk populations, particularly in resource-limited settings (Budd et al., 2020; Donelle et al., 2023; Vaishya et al., 2020).

Trends in publication and citation volume reveal an exponential rise in scholarly attention to this area, especially during the COVID-19 period, which catalyzed the integration of digital technologies into healthcare systems. The spike in research output and citations between 2020 and 2024 underscores the positioning of artificial intelligence (AI) as a strategic instrument in responding to global health challenges and enhancing the precision of vulnerability assessments (Côté et al., 2024; Zaidan, 2023). These developments highlight AI's growing influence on public health practice and policymaking at both national and regional levels (Panteli et al., 2025).

The analysis of the most influential articles shows that even publications not directly focused on ML algorithms have become foundational references in the development of predictive models for health risk and vulnerability. This highlights the continued importance of foundational literature and clinical guidelines in supporting AI applications in healthcare. Contributions from articles on clinical recommendations and nutrition guidelines demonstrate that successful AI implementation must be grounded in robust empirical frameworks (Vatamanu & Tofan, 2025).

Cross-national collaboration analysis reveals that the United States remains at the center of the global research network, maintaining strong connections with countries such as China and the United Kingdom. This pattern illustrates that the development of AI in public health is influenced not only by technical factors but also by cultural, linguistic, and funding policy considerations (Baclic et al., 2020; Davies et al., 2024). These collaborative dynamics reinforce the U.S.'s role as an innovation hub, while also creating opportunities for other countries to expand their research capacity through strategic partnerships. AI holds immense potential to bridge health disparities, particularly for underserved populations (da Silva et al., 2024).

Overall, this study presents a comprehensive overview of the current developments and challenges in applying AI to regional NCD vulnerability. Its contribution extends beyond enriching the scientific literature, it offers strategic guidance for policymakers, researchers, and public health practitioners seeking to harness AI technologies effectively. By integrating data, international collaboration, and technological innovation, this field holds significant potential to revolutionize how we understand and address the global and regional burden of NCDs.

CONCLUSION

Artificial intelligence (AI) offers considerable promise in strengthening health policy implementation, especially in the early identification and management of geographic areas vulnerable to non-communicable diseases (NCDs). As data sources become more integrated and international collaboration intensifies, AI enhances the precision of risk area detection, thereby supporting more focused and efficient public health responses. Equally important is the need to invest in AI infrastructure and expertise in low- and middle-income countries to ensure that these technological advancements are accessible across settings and do not inadvertently widen existing health inequalities.

REFERENCE

Al-Karawi, D., Al-Zaidi, S., Helael, K. A., Obeidat, N., Mouhsen, A. M., Ajam, T., Alshalabi, B. A., Salman, M., & Ahmed, M. H. (2024). A Review of Artificial Intelligence in Breast Imaging. In *Tomography* (Vol. 10, Number 5, pp. 705–726). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/tomography10050055

B. Marqas, R., Mousa, A., Özyurt, F., & Salih, R. (2023). A Machine Learning Model for the Prediction of Heart Attack Risk in High-Risk Patients Utilizing Real-World Data. *Academic Journal of Nawroz University*, *12*(4), 286–301. https://doi.org/10.25007/ajnu.v12n4a1974

Baclic, O., Tunis, M., Young, K., Doan, C., Swerdfeger, H., & Schonfeld, J. (2020). Challenges and opportunities for public health made possible by advances in natural language processing. *Can Commun Dis Rep*, *46*(6), 161–168. https://doi.org/10.14745/ccdr.v46i06a02

Bernardi, F. A., Alves, D., Crepaldi, N. Y., Yamada, D. B., Lima, V. C., & Lopes Rijo, R. P. C. (2023). Data Quality in health research: a systematic literature review. In *J Med Internet Res*. https://doi.org/10.1101/2022.05.31.22275804

Budd, J., Miller, B. S., Manning, E. M., Lampos, V., Zhuang, M., Edelstein, M., Rees, G., Emery, V. C., Stevens, M. M., Keegan, N., Short, M. J., Pillay, D., Manley, E., Cox, I. J., & Heymann, D. (2020). Digital technologies in the public-health response to COVID-19. *Nature Medicine*, *26*(August), 1183–1192. https://doi.org/10.1038/s41591-020-1011-4

Côté, J.-N.; Germain, M.; Levac, E.; Lavigne, E. (2024). Vulnerability assessment of heat waves within a risk framework using artificial intelligence. *Science of the Total Environment*, *912*(169355). https://doi.org/10.1016/j.scitotenv.2023.169355

Davies, G. K., Luther, M., Davies, K., Adewusi, E., Moneke, K., Adeleke, O., Mosaku, L. A., Oboh, A., Shaba, D. S., Katsina, I. A., Egbedimame, J., & Ssentamu, R. (2024). AI-Enhanced Culturally Sensitive Public Health Messaging: A Scoping Review. *E-Health Telecommunication Systems and Network*, 45–66. https://doi.org/10.4236/etsn.2024.134004

Donelle, L., Comer, L., Hiebert, B., Hall, J., Shelley, J., Smith, M. J., Kothari, A., Burkell, J., Stranges, S., Cooke, T., Shelley, J. M., Gilliland, J., Ngole, M., & Facca, D. (2023). *Use of digital technologies for public health surveillance during the COVID-19 pandemic: A scoping review*. https://doi.org/10.1177/20552076231173220

Fitzpatrick, P. J. (2023). Improving health literacy using the power of digital communications to achieve better health outcomes for patients and practitioners. *Front Digit Health*, (November), 1–13. https://doi.org/10.3389/fdgth.2023.1264780

Gurevich, E., El Hassan, B., & El Morr, C. (2023). Equity within AI systems: What can health leaders expect? *Healthcare Management Forum*, *36*(2), 119–124. https://doi.org/10.1177/08404704221125368

Hanna, M. G., Pantanowitz, L., Jackson, B., Palmer, O., Visweswaran, S., Pantanowitz, J., Deebajah, M., & Rashidi, H. H. (2025). Ethical and Bias Considerations in Artificial Intelligence/Machine Learning. In *Modern Pathology* (Vol. 38, Number 3). Elsevier B.V. https://doi.org/10.1016/j.modpat.2024.100686

Huang, J., Yeung, A. M., Armstrong, D. G., Battarbee, A. N., Cuadros, J., Espinoza, J. C., Kleinberg, S., Mathioudakis, N., Swerdlow, M. A., & Klonoff, D. C. (2023). Artificial Intelligence for Predicting and Diagnosing Complications of Diabetes. In *Journal of Diabetes Science and Technology* (Vol. 17, Number 1, pp. 224–238). SAGE Publications Inc. https://doi.org/10.1177/19322968221124583

Kalavar, M., Al-Khersan, H., Sridhar, J., Gorniak, R. J., Lakhani, P. C., Flanders, A. E., & Kuriyan, A. E. (2020). Applications of Artificial Intelligence for the Detection, Management, and Treatment of Diabetic Retinopathy. *International Ophthalmology Clinics*, *60*(4), 127–145. https://doi.org/10.1097/IIO.0000000000000333

Kemenkes, D. P. dan P. P. (2019). *Manajemen Penyakit Tidak Menular*.

Lu, T., Lin, Q., & Yu, B. (2025). A systematic review of strategies in digital technologies for motivating adherence to chronic illness self-care. *Npj Health Systems*. https://doi.org/10.1038/s44401-025-00017-4

Mason, M., Cho, Y., Rayo, J., Gong, Y., Harris, M., Ingalls, N., & Arbor, A. (2022). *Technologies for Medication Adherence Monitoring and Technology Assessment Criteria: Narrative Review Corresponding Author: 10*, 1–18. https://doi.org/10.2196/35157

Mohsen, S. (2025). Alzheimer's disease detection using deep learning and machine learning: a review. *Artificial Intelligence Review*, *58*(9). https://doi.org/10.1007/s10462-025-11258-y

Nurbaiti, Putra Syarif Hidayat, E., Anwar, K., Hermawan, D., Izzuddin, S., & Kemenkes Jakarta, P. I. (2024). Development of AI Models from Mammography Images for Early Detection of Breast Cancer. In *Generation Journal* (Vol. 8, Number 1). https://doi.org/https://doi.org/10.29407/gj.v8i1.21601

Ogunpola, A., Saeed, F., Basurra, S., Albarrak, A. M., & Qasem, S. N. (2024). Machine Learning-Based Predictive Models for Detection of Cardiovascular Diseases. *Diagnostics*, *14*(2). https://doi.org/10.3390/diagnostics14020144

Panteli, D., Adib, K., Buttigieg, S., Goiana-da-silva, F., Ladewig, K., Azzopardi-muscat, N., Figueras, J., Novillo-ortiz, D., & Mckee, M. (2025). Artificial intelligence in public health: promises , challenges , and an agenda for policy makers and public health institutions. *The Lancet Public Health*, *10*(5), e428–e432. https://doi.org/10.1016/S2468-2667(25)00036-2

Pati, M. K., Swaroop, N., Kar, A., Aggarwal, P., Jayanna, K., & Van Damme, W. (2020). A narrative review of gaps in the provision of integrated care for noncommunicable diseases in India. In *Public Health Reviews* (Vol. 41, Number 1). BioMed Central Ltd. https://doi.org/10.1186/s40985-020-00128-3

Peng, W., Chen, S., Chen, X., Ma, Y., Wang, T., Sun, X., Wang, Yaogang, Ding, G., & Wang, Youfa. (2024). Trends in major non-communicable diseases and related risk factors in China 2002–2019: an analysis of nationally representative survey data. *The Lancet Regional Health - Western Pacific*, *43*. https://doi.org/10.1016/j.lanwpc.2023.100809

Saleem, T. J., Zahra, S. R., Wu, F., Alwakeel, A., Alwakeel, M., Jeribi, F., & Hijji, M. (2022). Deep Learning-Based Diagnosis of Alzheimer's Disease. In *Journal of Personalized Medicine* (Vol. 12, Number 5). MDPI. https://doi.org/10.3390/jpm12050815

Samuel Adelusi, B., Osamika, D., Chinyeaka Kelvinagwu, M., Yetunde Mustapha, A., & Ikhalea, N. (2024). *A Data-Driven Framework for Early Detection and Prevention of Non-Communicable Diseases in Healthcare Systems*.

Sanga, S. G., & Bhavana, S. (2025). *Social Sciences & Humanities Open Revolutionizing healthcare with an in-depth analysis of AI' s transformative impact in India*. *11*(September 2024).

Silva Jr. JB, Lima NT, Haddad AE, Gross Galiano S, Garcia Saiso S, Valdez ML, et al. (2024). From national and regional commitments to global impact: artificial intelligence for equitable public health at the G20. *Rev Panam Salud Publica*, *48*(e73). https://doi.org/10.26633/RPSP.2024.73

St-Pierre, Julie., Gauthier, Annie., & Pollet, Romane. (2023). *The use of the concept of vulnerability in* *public health*. Institut national de santé publique du Québec.

Subramanian, M., Wojtusciszyn, A., Favre, L., Boughorbel, S., Shan, J., Letaief, K. B., Pitteloud, N., & Chouchane, L. (2020). Precision medicine in the era of artificial intelligence: implications in chronic disease management. In *Journal of Translational Medicine* (Vol. 18, Number 1). BioMed Central Ltd. https://doi.org/10.1186/s12967-020-02658-5

Torabi, Z., Shakibazadeh, E., Tajvar, M., & Rezaei, N. (2025). Non-communicable diseases challenges and opportunities in Iran: a qualitative study. *Scientific Reports*, *15*(1). https://doi.org/10.1038/s41598-025-92897-7

Vaishya, R., Javaid, M., Haleem, I., & Haleem, A. (2020). Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes and Metabolic Syndrome*, *14*(4), 337–339. https://doi.org/10.1016/j.dsx.2020.04.012

Vargas-Santiago, M., León-Velasco, D. A., Maldonado-Sifuentes, C. E., & Chanona-Hernandez, L. (2025). A State-of-the-Art Review of Artificial Intelligence (AI) Applications in Healthcare: Advances in Diabetes, Cancer, Epidemiology, and Mortality Prediction. In *Computers* (Vol. 14, Number 4). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/computers14040143

Varnosfaderani, S. M., & Forouzanfar, M. (2024). *The Role of AI in Hospitals and Clinics: Transforming Healthcare in the 21st Century*. 1–38.

Vatamanu, A. F., & Tofan, M. (2025). Integrating Artificial Intelligence into Public Administration: Challenges and Vulnerabilities. *Administrative Sciences*, *15*(4), 149. https://doi.org/10.3390/admsci15040149

Wang, L. (2024). Mammography with deep learning for breast cancer detection. In *Frontiers in Oncology* (Vol. 14). Frontiers Media SA. https://doi.org/10.3389/fonc.2024.1281922

WHO. (2023). *Noncommunicable diseases*. Https://Www.Who.Int/News-Room/Fact-Sheets/Detail/Noncommunicable-Diseases.

Xiao, S., Dong, Y., Xia, Y., Xu, H., Weng, F., Liang, G., Yi, Q., & Ai, C. (2024). Current Trends in Chronic Non-Communicable Disease Management: A Bibliometric Analysis of the Past Two Decades. *Journal of Multidisciplinary Healthcare*, *17*, 5001–5017. https://doi.org/10.2147/JMDH.S482427

Yao, Z., Wang, H., Yan, W., Wang, Zheling, Zhang, W., Wang, Zhiguo, & Zhang, G. (2023). Artificial intelligence-based diagnosis of Alzheimer's disease with brain MRI images. In *European Journal of Radiology* (Vol. 165). Elsevier Ireland Ltd. https://doi.org/10.1016/j.ejrad.2023.110934

Zaidan, A. M. (2023). The leading global health challenges in the artificial intelligence era. *Front Public Health*, (November), 1–10. https://doi.org/10.3389/fpubh.2023.1328918

Zuhair, V., Babar, A., Ali, R., Oduoye, M. O., Noor, Z., Chris, K., & Okon, I. I. (2024). *Exploring the Impact of Artificial Intelligence on Global Health and Enhancing Healthcare in Developing*. https://doi.org/10.1177/21501319241245847