ISSN 2548-6462 (online), ISSN 2088-8740 (print)

DOI: 10.30644/rik.v15i1.1091

Indonesian radiology research metrics and their alignment with the sustainable development goals

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Accepted: 2 September 2025; revision: 2 September 2026; published: 31 January 2026

Abstract

Background: Radiology is one of the most dynamic and essential fields in modern medicine. However, few studies have systematically examined the development trends, terminology, and contributions of Indonesian radiology literature to the achievement of the Sustainable Development Goals (SDGs). This study aims to analyze bibliometric trends and the alignment of Indonesian radiology research with the SDGs from 2015 to mid-2025.
Method: This study uses a bibliometric review of 84 selected documents published by Scopus database, with assistance from three major tools: Bibliometrix R Package, VOSviewer, and SDGs Mapper.
Results: The results reveal fluctuating publication trends and a general decline in annual citation rates. Atom Indonesia emerged as the most prolific source, while the Bali Medical Journal has shown increased contributions in recent years. The most productive author was Oscandar F., followed by Yusra, noted for cross-institutional collaboration. Universitas Indonesia led in publication volume, and the article by Saktiawati et al. (1) received the highest citations. The United Kingdom was the most frequent international collaborator. Key thematic focuses included "tuberculosis," "diagnostic imaging," and "thorax radiography," with emerging topics such as "orthopedics" and "cancer risk." Notably, 83.2% of SDG-related publications contributed to SDG 3, underscoring the centrality of health issues in national radiology research.
Conclusion: In sum, this study offered a comprehensive overview of the Indonesian radiology research landscape and its relevance to sustainable development goals.

Keywords: Radiology research; radiography; trend topic; SDGs; Indonesia.

INTRODUCTION

Radiology represents a cornerstone of modern healthcare systems, serving not only a pivotal role in diagnosis and treatment but also contributing meaningfully to the advancement of sustainable development goals (SDGs), particularly Goal 3: Good Health and Well-being. In Europe, the evolution of radiological research reflects a growing trend aligned with technological advancements and the increasing demand for more effective healthcare services, as evidenced by previous studies (2–5). Nonetheless, the extent to which this body of research aligns with broader global agendas such as the SDGs remains insufficiently explored in a systematic manner. Evaluating research metrics, including publication volume, international collaboration, and scientific impact, is essential to assess radiology's tangible contributions to SDG-related targets such as strengthening health systems, improving healthcare accessibility, and fostering medical innovation (6,7).

Indeed, the SDG framework explicitly highlights key targets directly relevant to diagnostic imaging in global health, encompassing not only improvements in

health and well-being but also innovation, infrastructure development, and the reduction of inequalities (8). Consequently, a systematic analysis of radiology research metrics in relation to the SDGs can yield strategic insights for shaping more sustainable national and international research policies.

In the context of Indonesia, a country grappling with the dual challenges of managing a rising burden of chronic diseases and an overstretched healthcare system (9,10), this becomes particularly pressing. The growing prevalence of chronic conditions, an aging population, and infrastructural limitations have led to increased morbidity and mortality rates (11), positioning radiological services as an increasingly critical component of the healthcare landscape (12). However, the expansion of this sector is hindered by significant barriers, including high costs, public concerns over radiation exposure, and a persistent shortage of qualified radiologists (13), all of which limit the sector's growth and its potential to contribute to sustainable healthcare outcomes.

Studies examining the evolution of research trends in radiology have been conducted for decades, revealing a progressively expanding field across different regions of the world. In Europe, radiological literature has seen substantial growth within the scientific community (5). Similarly, a marked increase in scholarly output is evident in East Asia, particularly South Korea, where meta-analytical studies have predominantly focused on key domains such as oncology, gastroenterology, and endocrinology (14).

In addition, several investigations have compared the most cited and most downloaded articles within radiology journals, including assessments of the bibliometric indicators used (4). A related study of the most frequently cited papers in the fields of radiology, nuclear medicine, and medical imaging has highlighted the prevalence of keywords such as "deep learning", "COVID-19", and "MRI" (15). Moreover, the trend of increasing numbers of authors per publication since the early 1990s has been noted, reflecting the growing complexity of research and its implications for indexing systems like MEDLINE (3).

Bibliometric analyses combining the themes of radiology and trauma have also been conducted (16), alongside investigations into the declining publication trends in the journal Radiología, particularly within the subfields of gastrointestinal radiology and neuroradiology (17). Notably, a study of the 100 most-cited articles in head and neck radiology has provided valuable insights into the global literature landscape (18). The field of interventional radiology (IR) also shows a steady increase in publication output, mirroring broader trends across medical research (2).

Retrospective bibliometric analyses in the subfield of artificial intelligence in radiology have demonstrated rapid progress, with an emphasis on emerging themes such as deep learning, convolutional neural networks, and magnetic resonance imaging (MRI) (19). Despite these diverse and geographically varied studies, to the best of our knowledge, no comprehensive analysis has yet been conducted to specifically evaluate the contributions of radiological literature in the context of the United Nations Sustainable Development Goals (SDGs). This gap is particularly noteworthy, given that the intersection between radiological science and global development objectives represents a critical yet underexplored area. It is anticipated that this study will provide a comprehensive overview of the positioning and relevance of Indonesian radiology scholarship within the global academic landscape. Furthermore, it seeks to serve as a foundational reference for future research initiatives aiming to integrate radiological studies with sustainable development agendas at an international scale. Accordingly, this study is designed to examine the following objectives:

a. RQ1: To what extent have publication metrics in the field of radiology in Indonesia evolved over recent years?
b. RQ2: What are the prevailing themes or frequently occurring terms in Indonesian radiology publications?

c. RQ3: To what degree do radiology-related publications from Indonesia contribute to the achievement of targets and indicators outlined in the Sustainable Development Goals (SDGs)?

METHOD

A total of 84 documents were ultimately included in this study, as illustrated in Figure 1, following a systematic selection process based on the PRISMA framework. These documents were retrieved exclusively from the Scopus database, selected due to its global recognition as a comprehensive and high-quality repository of scholarly literature, underpinned by robust citation metrics and rigorous indexing standards (20,21).

This study employed a retrospective bibliometric approach, which is considered particularly suitable for examining the historical development of scientific publications. Through bibliometric techniques, it is possible to reveal various publication trends and indicators, including document volume, research fragmentation, and prevailing thematic concentrations within specific disciplinary domains (22). Moreover, this approach enables a quantitative assessment of scholarly output in terms of authorship patterns, citation dynamics, and scientific impact (23).

For data analysis and visualization, the Bibliometrix package in the R environment was utilized. This tool facilitates the generation of diverse bibliometric indicators such as the most prolific authors, most cited documents, annual publication distribution, and the most active journals in the field, among others (24). Complementarily, VOSviewer software was employed to explore term co-occurrence patterns, keyword trends, and to construct visual networks through overlay analyses based on term attributes extracted from the dataset (25,26). Additionally, SDGs Mapper was used to identify the alignment of the documents with the United Nations Sustainable Development Goals (SDGs). A bar chart was utilized to provide a general overview of the representation of each SDG across the corpus, while a bubble chart offered a more nuanced depiction of the relationships between individual goals and their associated targets (27–29).

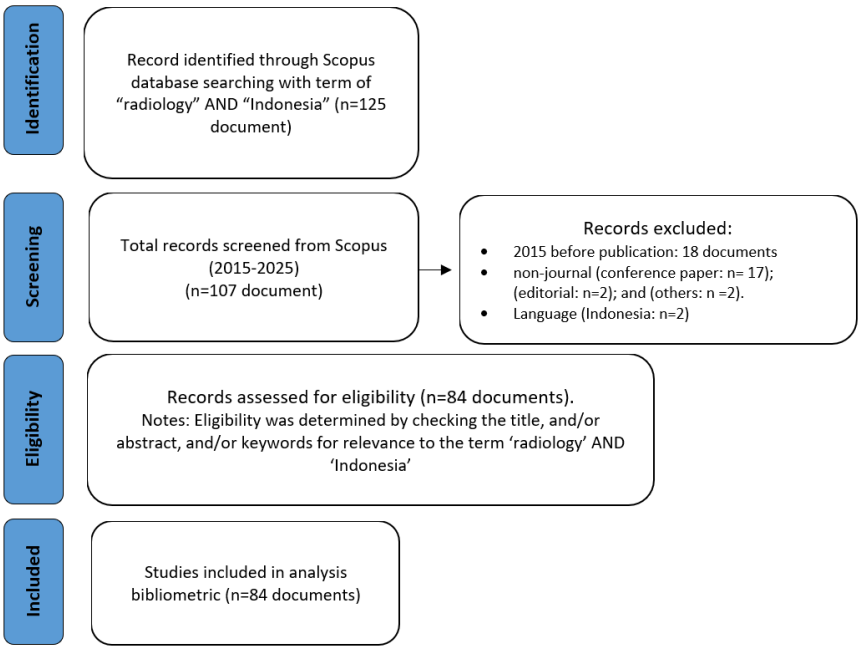

Figure 1. PRISMA Framework

Noted: last documents received from Scopus on August 22, 2025.

ISSN 2548-6462 (online), ISSN 2088-8740 (print)

The data analyzed in this study were retrieved from the Scopus database using the keywords "radiology" and "Indonesia". The initial search yielded 125 documents. A subsequent screening process was conducted by applying a temporal filter covering a ten-year span from 2015 to mid-2025, aligning with the onset of the SDG implementation timeline in 2015. This refinement resulted in 107 documents after excluding non-article types and non-English texts. A further eligibility assessment was conducted by manually reviewing titles, abstracts, and keywords to ensure the explicit presence of both “radiology” and “Indonesia”. As a result, 84 documents met the inclusion criteria and were retained for further bibliometric analysis.

Figure 2. Main Information

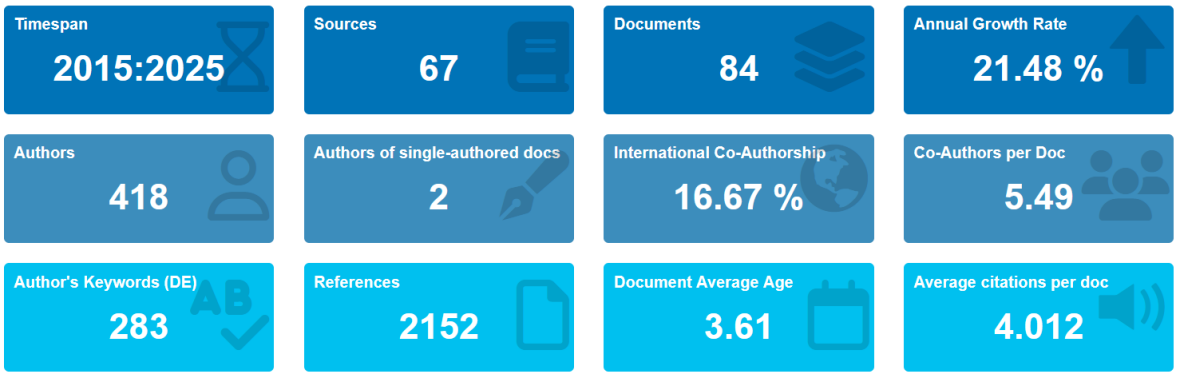

Figure 2 illustrates the bibliometric data spanning the period from 2015 to 2025, revealing a progressive and substantial increase in scientific productivity and collaboration. A total of 84 documents were published across 67 sources, with an annual growth rate of 21.48%, indicating a consistently upward trajectory in research activity. The level of collaboration is notably high, as reflected by an average of 5.49 authors per document, with only two publications authored individually. Furthermore, 16.67% of the documents involved international collaboration, suggesting the presence of a global research network contributing to knowledge production.

In terms of scholarly quality and impact, the average citation rate of 4.012 citations per document suggests a moderate level of scientific influence particularly when considering the relatively young average age of the documents, which stands at 3.61 years. The dataset also comprises over 2,000 references and 283 distinct keywords, indicating a wide thematic range and extensive literature coverage. This diversity reinforces the theoretical and conceptual foundations of the publications included in the corpus. Taken together, these data suggest the emergence of a maturing and increasingly dynamic research ecosystem within the studied domain.

RESULTS

Yearly publication and citation analysis

This component is essential for understanding the temporal dynamics of scientific productivity and scholarly impact within a particular field or by specific researchers. Through such analysis, it becomes possible to identify trends in publication growth, citation fluctuations, and the correlation between publication timing and the accumulation of scientific influence. These insights enable the evaluation of research strategies over time, the identification of peak productivity periods, and the detection of potential declines or improvements in the quality of scholarly output from a longitudinal perspective.

Table 1. Annual scientific production and average citations per year

Year	N	MeanTCperArt	MeanTCperYear	CitableYears
2015	1	18.00	1.64	11
2016	2	6.50	0.65	10
2017	2	2.50	0.28	9
2018	5	5.80	0.72	8
2019	8	5.75	0.82	7
2020	12	4.67	0.78	6
2021	13	7.46	1.49	5
2022	10	2.40	0.60	4
2023	10	3.10	1.03	3
2024	14	1.29	0.64	2
2025	7	0.00	0.00	1

Based on the data presented in Table 1: Annual Scientific Production and Average Citations per Year, a notable upward trend in scientific productivity is evident between 2015 and 2024, with the number of publications increasing from a single article in 2015 to 14 articles in 2024. However, this quantitative growth does not necessarily correspond with a proportional increase in scholarly impact or quality, as reflected by the fluctuations and in some cases, declines in both the mean total citations per article (MeanTCperArt) and the average citations per year (MeanTCperYear).

The year 2015 recorded the highest MeanTCperArt (18.00), likely attributable to the longer citation window available for those publications (CitableYears = 11). In contrast, more recent years with higher publication volumes, such as 2020–2024, exhibited relatively lower values for both MeanTCperArt and MeanTCperYear. This suggests that many of the more recent articles have yet to generate significant scholarly impact or have not had sufficient time to accumulate citations. This pattern is particularly evident in 2025, where both citation metrics were recorded as zero, given that the publications have only been citable for one year (CitableYears = 1).

These findings underscore the critical importance of incorporating temporal dimensions in bibliometric evaluations. The time elapsed since publication plays a key role in citation accumulation and, consequently, in measuring scholarly impact. Overall, while the increasing trend in scientific output reflects positive momentum in research productivity, impact and quality remain essential dimensions that must be assessed through a comprehensive and time-aware bibliometric lens.

Source Analysis

This section plays a critical role in bibliometric analysis as it facilitates the identification of the most productive and influential publication sources within a specific field of study. Through source analysis, it becomes possible to determine which journals or proceedings serve as primary platforms for disseminating research, while also evaluating the quality and relevance of these outlets in relation to the advancement of scientific knowledge.

Moreover, source analysis supports researchers in identifying high-visibility publication targets, enabling more strategic dissemination of their work. It also helps map the dynamics of knowledge distribution by assessing the credibility and scope of various sources. As such, this analysis provides an evidence-based foundation for making informed decisions regarding scholarly publishing, research collaboration, and the future direction of academic inquiry.

Table 2. Sources Most relevant sources

Sources	Articles

Atom Indonesia	4
Bali Medical Journal	3
International Journal of Electrical and Computer Engineering	3
Althea Medical Journal	2
Dental Journal	2
European Journal of Orthopaedic Surgery and Traumatology	2
F1000research	2
Indian Journal of Forensic Medicine and Toxicology	2
Journal of Dentomaxillofacial Science	2
Malaysian Journal of Medicine and Health Sciences	2
Open Access Macedonian Journal of Medical Sciences	2
Plos One	2
Radiology Case Reports	2

Note: At least the sources have two document publications selected

Table 2 identifies the most relevant publication sources that serve as primary outlets for disseminating research findings within the analyzed period. Atom Indonesia emerges as the most prolific source, contributing four articles, followed by the Bali Medical Journal and the International Journal of Electrical and Computer Engineering, each publishing three articles. Additionally, a variety of journals spanning multiple disciplines including medicine, dentistry, and forensics are represented, alongside reputable international open-access journals such as PLOS ONE and F1000Research, each contributing two articles.

This diversity of sources reflects a broad and multidisciplinary research spectrum, indicating a knowledge distribution pattern that extends beyond local boundaries to engage the global scientific community. Consequently, source analysis is crucial for understanding both the concentration and diversification of publications, while also aiding researchers in identifying strategic journal targets to enhance the visibility and impact of their work.

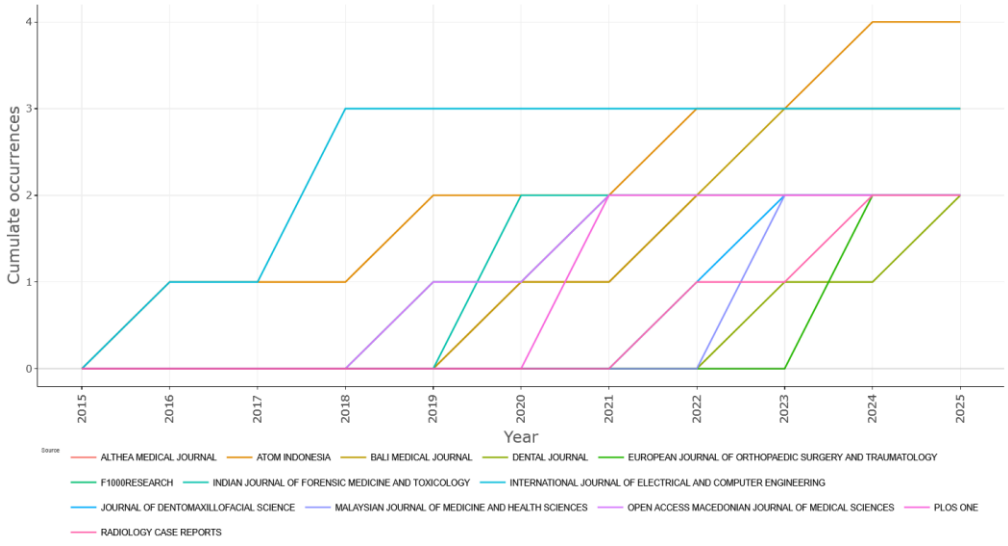

Figure 3. Yearly production document by source

Figure 3 illustrates the temporal distribution and publication intensity across various journals over the period from 2015 to 2025, highlighting the heterogeneity in contribution patterns among different scientific sources. Journals such as Atom

Indonesia and the International Journal of Electrical and Computer Engineering demonstrate stable and early dominance, with a steadily increasing accumulation of articles that peak during the mid-to-late years of the period. In contrast, other journals like the Bali Medical Journal, PLOS ONE, and F1000Research exhibit more sporadic participation, with noticeable growth predominantly occurring in the later years, reflecting a phase of expansion or emerging penetration within the publication landscape.

This phenomenon underscores the multidisciplinary dynamics and the evolving network of publication sources, encompassing both well-established journals and those with growing visibility and impact. Therefore, it is emphasizes the importance of understanding temporal publication patterns to optimize scientific dissemination strategies, while identifying potential opportunities for collaboration and source diversification that could broaden the reach and relevance of future research.

Authors Analysis

This section plays a pivotal role in understanding the contributions of individual researchers and research groups to the advancement of scientific knowledge. By examining patterns of productivity, collaboration, and author distribution within publications, this analysis facilitates the identification of key influencers driving research activities, as well as the assessment of the extent of scholarly cooperation. Furthermore, author mapping enables the evaluation of academic networks and the potential for interdisciplinary or interinstitutional collaborations, which are critical for enhancing the quality and impact of research. Therefore, author analysis not only provides a quantitative overview of individual contributions but also serves as a strategic foundation for fostering research communities and informing science policy development.

Table 3. Most relevant author

Authors	Articles	Articles Fractionalized
Oscandar F	4	0.87
Chusida A	3	0.35
Dilogo Ih	3	0.78
Kurniawan A	3	0.35
Rizky Bn	3	0.35

Note: At least the author has three document publications selected

Table 3 presents a list of the most relevant authors based on the number of articles published during the analyzed period, with a minimum threshold of three publications per author. From this table, OSCANDAR F ranks highest with a total of four articles and a fractionalized article score of 0.87, indicating a dominant contribution within collaborative publications despite the joint nature of the work. Other authors, including CHUSIDA A, DILOGO IH, KURNIAWAN A, and RIZKY BN, each contributed three articles; however, their fractionalized scores vary. Notably, DILOGO IH (0.78) demonstrates a more substantial involvement compared to others with lower fractionalized values (e.g., 0.35).

The fractionalized score reflects the individual share of contribution within collaborative efforts, offering a more precise measure of each author's active role in the publications. Overall, this table highlights the presence of a core group of consistently active authors in scientific production while emphasizing the importance of fractionalized analysis in understanding the distribution of individual contributions within collaborative research.

Figure 4 depicting author productivity illustrates the temporal distribution of scholarly contributions by various authors

over the period from 2016 to 2025, with bubble sizes representing the intensity of publications in each respective year. Key authors such as Oscandar F, Chusida A, and Dilogo IH demonstrate sustained research activity, exhibiting quantitative fluctuations that highlight peak productivity during specific years. Conversely, several other authors display more sporadic and limited contributions over shorter time spans, indicating variability in research engagement levels.

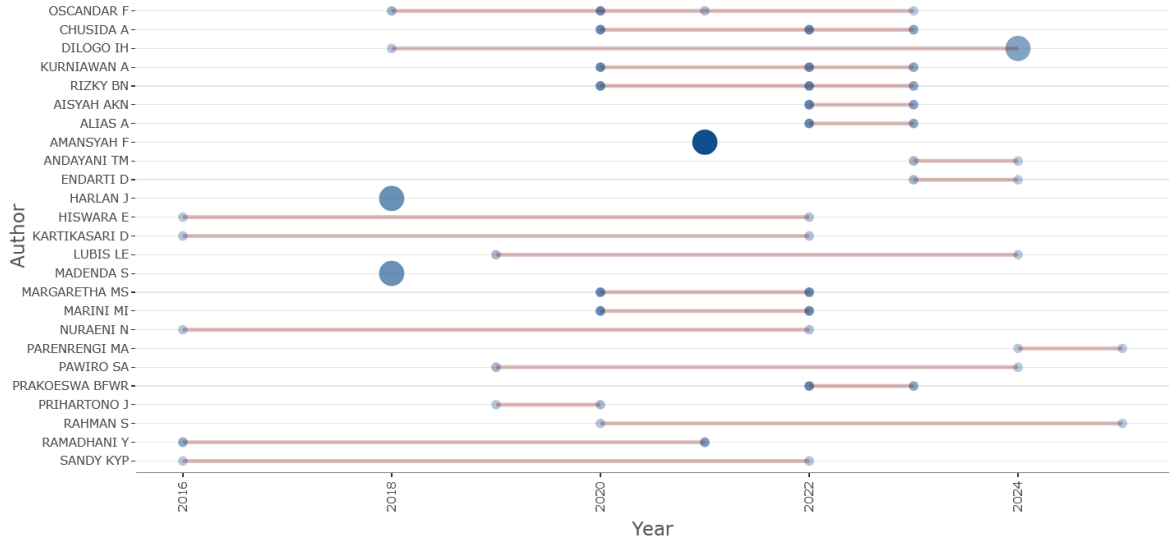

Figure 4. Authors production overtime

The emergence of authors who became active in recent years further signifies a dynamic intellectual regeneration within the radiology research community in Indonesia, which is essential for sustaining continuity and fostering innovation. This visualization not only reflects the temporal heterogeneity of individual contributions but also provides strategic insights for managing human resources in research, as well as identifying opportunities to develop more robust and sustainable collaborative networks.

Figure 5, illustrating the author collaboration network, revealed the existence of two relatively segregated research clusters that were interconnected through a central figure, namely Yusra. Yusra acted as a nexus bridging these two academic communities, as evidenced by articles published in collaboration with colleagues (30,31). The dense connectivity within each cluster reflected strong internal cohesion and likely specific thematic focus, while the strategic position of the central author indicated a vital role in bridging academic social fragmentation.

The presence of this bridging figure was crucial in facilitating intellectual exchange across groups, expanding collaborative reach, and enhancing the dynamics of interdisciplinary research innovation. Thus, this analysis not only underscored the importance of social networks in the advancement of knowledge but also provided strategic insights for optimizing synergy among researcher groups to strengthen a more inclusive and productive research ecosystem.

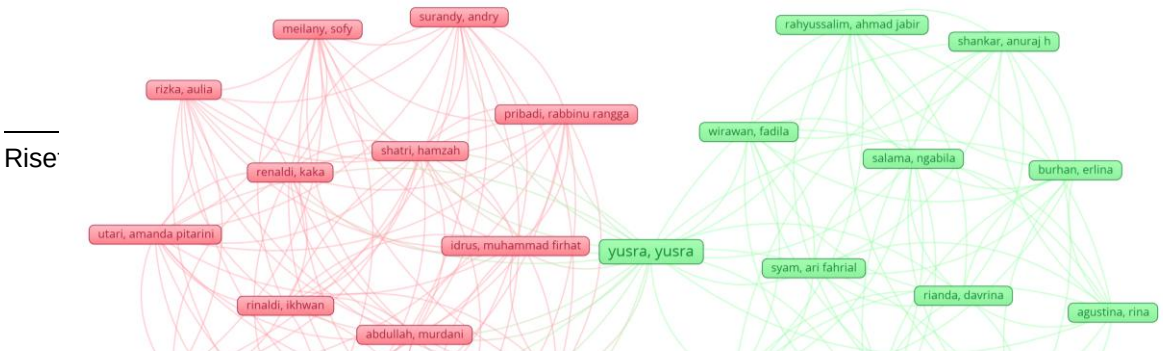

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Figure 5. Authors network collaboration

Affiliation Analysis

This section plays a fundamental role in understanding the institutional context underpinning scientific production by tracing the contributions of the institutions or organizations with which researchers are affiliated. The significance of this analysis lies in its ability to identify key institutions serving as centers of research and innovation, while also evaluating collaborative networks among institutions at both regional and global levels.

Furthermore, understanding the distribution of affiliations can reveal patterns of concentration or diversification of research resources, with strategic implications for funding policies and capacity-building initiatives. Consequently, affiliation analysis not only provides a quantitative overview of institutional contributions but also serves as a crucial tool for designing effective collaborations that support the growth of a sustainable research ecosystem.

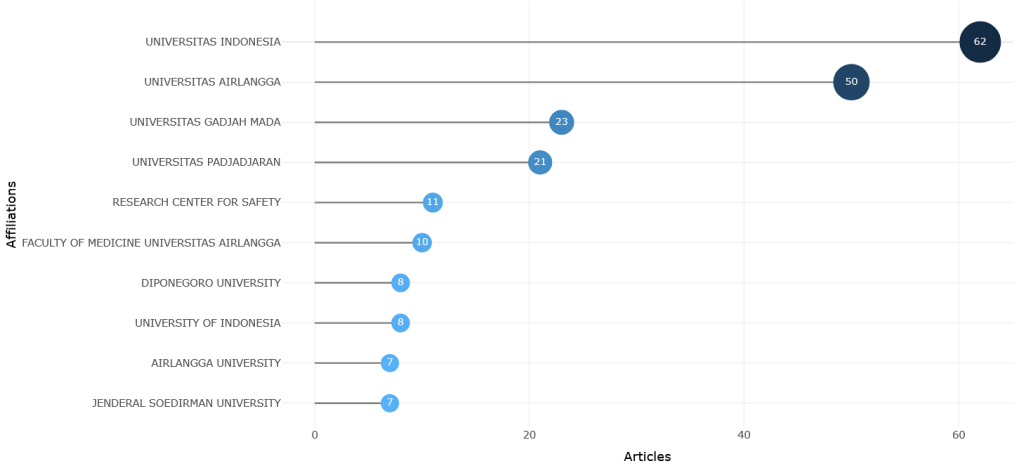

Figure 6. Most relevant affiliation
Note: At least the affiliation has seven document publications selected

Figure 6, illustrating the distribution of publications by institutional affiliation, revealed the significant dominance of Universitas Indonesia and Universitas Airlangga as the two primary research centers, contributing 62 and 50 articles respectively, thereby underscoring their central positions within the national academic landscape. The strategic roles of these institutions reflected their superior research

capacity, supported by adequate human resources, facilities, and institutional policies conducive to scientific productivity. Meanwhile, the presence of institutions such as Universitas Gadjah Mada, Universitas Padjadjaran, and the Research Center for Safety added dimensions of diversity to the sources of research, while also indicating fragmentation in research capacity that warranted attention.

The disparity in publication distribution across institutions highlighted the need for a more integrated and inclusive approach in developing the research ecosystem, including enhancing cross-institutional collaboration and more strategic allocation of resources. Consequently, this affiliation analysis not only provided a quantitative overview of institutional contributions but also served as a critical foundation for formulating research policies aimed at equity and quality improvement in national scientific output.

Figure 7, depicting the cumulative annual publication trends based on institutional affiliations, demonstrated significant growth in research productivity among several leading universities from 2015 to 2025. Universitas Indonesia exhibited the steepest acceleration in publications, with consistent increases culminating in the highest peak among all institutions, thereby consolidating its position as a dominant research hub. Universitas Airlangga followed with rapid growth since 2019, reflecting substantial expansion in research capacity in recent years.

In contrast, Universitas Gadjah Mada and Universitas Padjadjaran showed more moderate but stable growth, indicating consistent scholarly contributions. The Research Center for Safety, on the other hand, displayed a delayed start in publications and comparatively slower growth, though it showed signs of progress beginning in 2025. This pattern illustrated disparities in research capacity across institutions and underscored the importance of strategies to strengthen collaboration and resource support to accelerate productivity in developing institutions. Overall, these trends indicated an increasingly competitive research ecosystem with potential for more inclusive and integrated development.

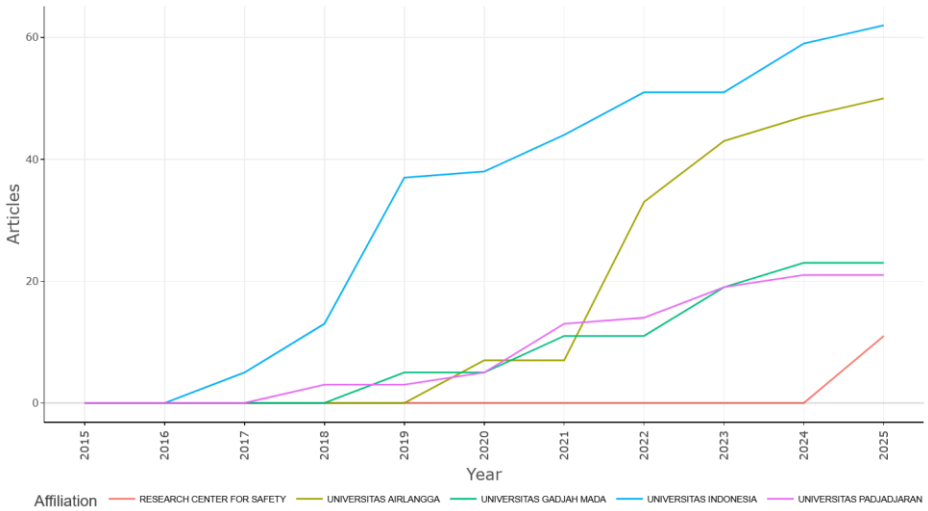

Figure 7. Affiliation production overtime

Citation Analysis

This section plays a crucial role in evaluating the impact and scientific relevance of individual works or groups of publications within the academic community. By measuring citation frequency, this analysis not only identifies the most influential works but also reveals trends in knowledge development and intellectual networks within a specific field of study. The importance of citation analysis lies in its ability to provide

indicators of research quality and recognition, which form the basis for strategic decision-making regarding funding, collaboration, and research capacity development.

Moreover, citation analysis helps map relationships among authors and institutions, thereby enhancing understanding of collaboration patterns and the distribution of scientific influence. Consequently, citation analysis serves as an essential tool for objectively assessing research success and relevance, while simultaneously promoting improvements in quality and innovation within scientific production.

Table 4. Most Global Cited Document

Paper	Total Citations	TC per Year	Normalized TC
(1)	21	4.20	2.81
(32)	18	2.25	3.10
(33)	18	1.64	1.00
(34)	16	2.67	3.43
(35)	15	2.50	3.21
(36)	14	2.33	3.00
(37)	14	4.67	4.52
(38)	13	1.86	2.26
(31)	13	2.60	1.74
(39)	12	2.40	1.61
(40)	12	2.40	1.61
(41)	12	1.20	1.85
(42)	10	1.43	1.74
(43)	10	2.50	4.17

Note: At least there are ten cited per document publications selected, retrieved on August 31, 2025.

Table 4 presented the documents with the highest global citation counts, indicating works that had a significant impact within the scientific community. The paper by Saktiawati et al. (1), published in PLOS ONE, ranked first with a total of 21 citations and an average of 4.20 citations per year, demonstrating strong recognition and high contemporary relevance. However, when considering normalized total citations (Normalized TC), which adjust for disciplinary and publication year variations, Portnow et al. (37) in J Am Coll Radiol achieved the highest score (4.52), indicating a more intensive impact relative to its context.

Documents by Naàm et al. (32) and Kurniawan et al. (35) also exhibited notable citation performance with Normalized TC values of 3.10 and 3.21, respectively, underscoring the sustained contribution of their research. Meanwhile, older works such as Maharani et al. (33), despite having a considerable total citation count, showed a lower Normalized TC value (1.00), reflecting a relatively stable but not significantly increasing impact in recent years.

This analysis illustrated the importance of not only measuring absolute citation counts but also incorporating normalization to identify works with the strongest academic influence that remain relevant across time and disciplinary contexts. Therefore, Table 4 provided a comprehensive overview of research quality and impact, serving as a key reference for future studies and strategic research development.

Country Analysis

This section played a vital role in understanding the geographical distribution and global contributions to scientific development within a research field. By identifying the most productive and influential countries, the analysis revealed patterns of international collaboration, national research strengths, and disparities in research capacity

across regions. Such insights provided strategic guidance for policymakers, academic institutions, and stakeholders in allocating resources, building cross-national partnerships, and enhancing global research competitiveness.

Moreover, country analysis indicated trends in scientific advancement related to socio-economic contexts and national research policies, thereby deepening the understanding of factors driving innovation and academic progress. Consequently, this analysis served as a crucial tool for promoting more inclusive, collaborative, and sustainable research development at the international level.

Figure 8, illustrating the country collaboration network, depicted Indonesia as a central hub in radiology publications, demonstrating its dominance and intensive involvement in this research area. Indonesia not only acted as a primary contributor but was also extensively connected with countries across multiple continents, including Southeast Asia (Malaysia, Thailand, Vietnam, Singapore), South Asia (India, Bangladesh, Pakistan), Europe (Germany, Austria, Netherlands, United Kingdom), the United States, as well as Africa and the Middle East (Qatar, Jordan).

These connections indicated strong and diverse international collaborations, which were essential for enhancing the quality, quantity, and global impact of Indonesia's radiology publications. Such cross-country relationships not only expanded academic networks but also facilitated the exchange of knowledge, technology, and resources, enriching radiology research in Indonesia and accelerating innovation and development of more competitive scientific knowledge on a global scale. Thus, Indonesia's central position within network reflected its strategic role in international radiology research community and its significant potential to further expand scientific influence and collaborative efforts in the future.

Figure 8. Country network collaboration

Network Analysis

This section played a crucial role in understanding the patterns of relationships and interactions among various elements within a research domain, such as authors, institutions, sources, or countries. Through this approach, collaboration clusters, central influences, and information dissemination pathways within the scientific community were identified. Network analysis enabled researchers to observe how connectivity among actors either strengthened or hindered the advancement of knowledge, as well as to uncover key actors who served as the main drivers in a particular field.

Figure 9, keyword network visualization, revealed the complex interconnections among major topics in radiology research. Different colors represented thematically related groups, indicating significant clusters that illustrated diverse yet integrated research focuses. For instance, the red cluster demonstrated a close relationship between clinical symptoms such as cough, hypoxia, and pneumonia, reflecting studies on clinical manifestations of pulmonary diseases. Meanwhile, the green cluster highlighted topics related to lung cancer, chemotherapy, and advanced radiological techniques such as computed tomography, indicating a focus on diagnosis and treatment of cancer through radiological technology.

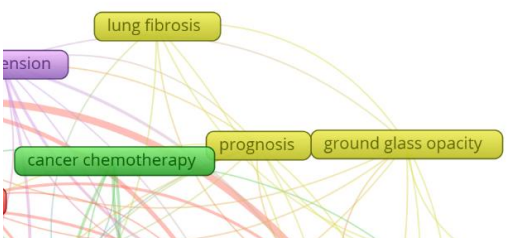

Figure 9. Terminology Network

The yellow cluster showed a focus on diseases such as tuberculosis and pulmonary fibrosis, indicating attention to chronic illnesses affecting lung tissue, while the blue cluster contained terminology related to diagnostic techniques like panoramic radiography and dental radiology, adding clinical and technical dimensions to the analysis. The connections between clusters, represented by linking lines, reflected crucial multidisciplinary integration in radiology research, combining clinical, diagnostic, and therapeutic aspects.

Overall, the keyword network analysis not only demonstrated the complexity and diversity of radiology research fields but also confirmed how various themes interacted to form a holistic understanding that could drive innovation and improve the quality of radiological services. This approach was essential for identifying research trends, strengthening interfield collaboration, and opening opportunities for strategic and clinically relevant interdisciplinary studies.

Figure 10 depicted the development of research in the field of radiology during the period from 2021 to mid-2022, with colors representing the emergence time and interconnections among key terms. Nodes colored in purple indicated terms that were more dominant at the beginning of the period, whereas yellow nodes represented newer and emerging terms. The analysis showed that terms such as "radiology," "thorax radiography," and "x-ray computed tomography" had the greatest weight and highest connectivity, indicating the primary research focus on chest imaging techniques and the use of CT scan technology in diagnosis.

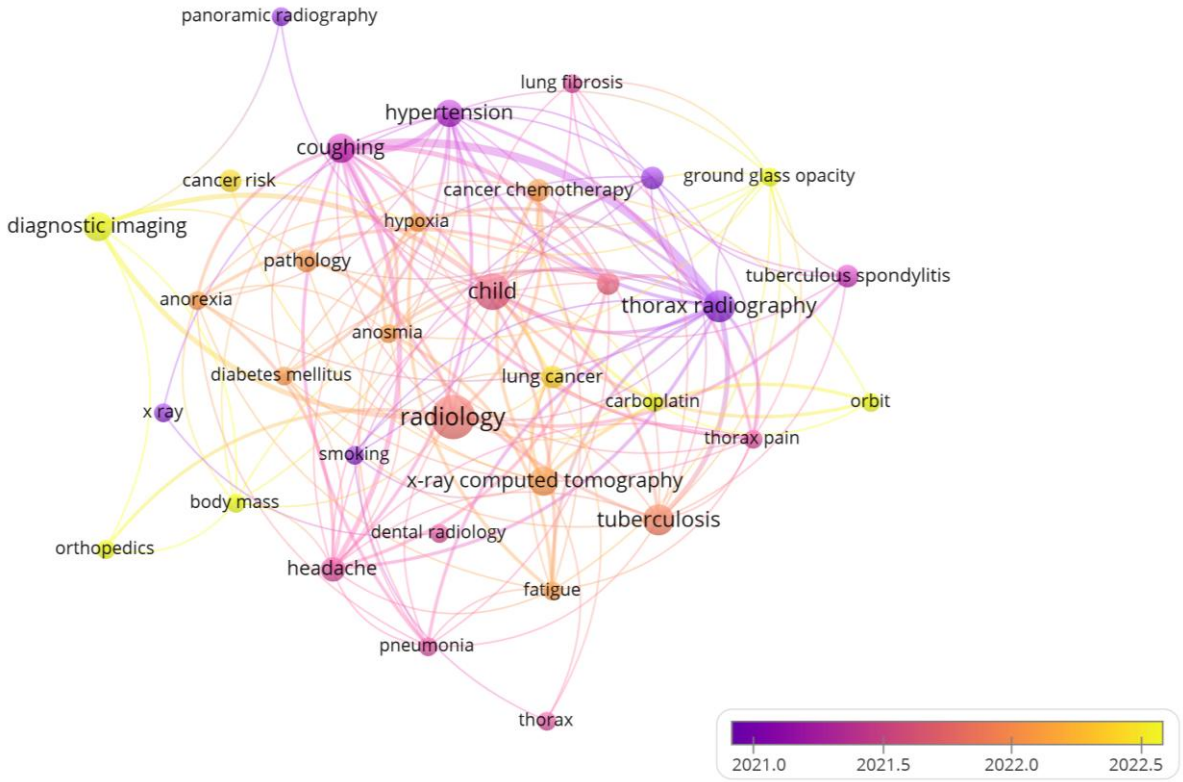

Figure 10. Terminology overlay network

The close associations between keywords like "lung cancer," "tuberculosis," and "coughing" revealed a significant focus on lung diseases and their complications, further supported by links to symptom-related terms such as "fatigue" and "headache." Treatment-related terms such as "carboplatin" and "cancer chemotherapy" also appeared in the network, demonstrating attention to therapeutic aspects within radiology research. Connections with other topics such as "diagnostic imaging," "body mass," and "orthopedics" indicated a diversification of radiology research encompassing various clinical and diagnostic aspects.

Overall, this network analysis provided comprehensive insights into the evolving dynamics of radiology research, where imaging technology and lung diseases remained central concerns. This approach was important for identifying current research trends, understanding relationships among research themes, and guiding the development of more integrated and innovative future studies.

Figure 11 illustrated the distribution of radiology research contributions in Indonesia in relation to the Sustainable Development Goals (SDGs). It was clearly observed that the majority of the research, amounting to 83.2%, focused on SDG 3, “Good Health and Well-being.” This reflected that radiology research in Indonesia was strongly directed toward improving public health and welfare. As mentioned by Pramono (44), patients presenting with clinical radiology symptoms were assessed not only through laboratory results but also through evaluations of well-being and unmet needs, ultimately aiming to provide optimal care quality for all chronic disease patients. This focus aligned with the primary priorities in both national and global development agendas.

ISSN 2548-6462 (online), ISSN 2088-8740 (print)

Sustainable Development Goals Analysis

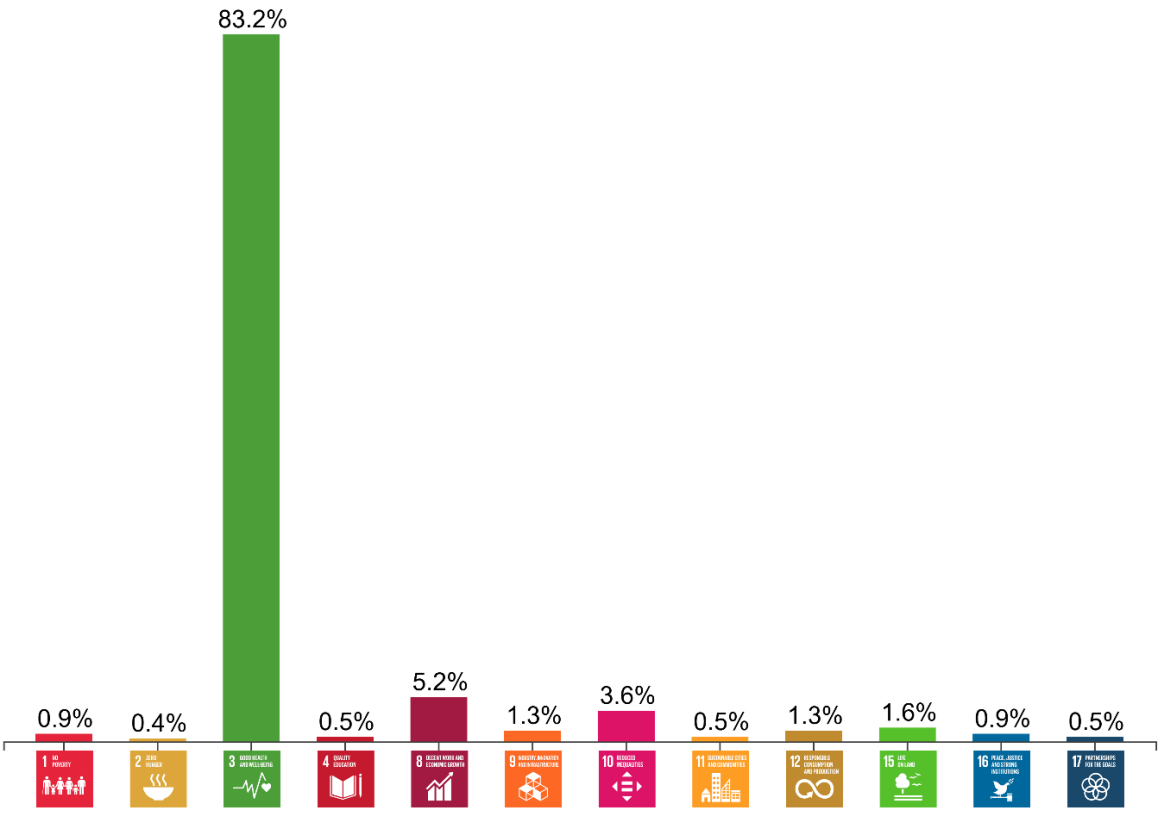

Figure 11. Relevent SDGs

Contributions to other SDGs were relatively minimal, with percentages below 6% for SDG 8 ("Decent Work and Economic Growth"), where crucial issues such as patient satisfaction with health management services in radiology facilities required dedicated efforts to improve public sector operations, including the physical appearance of facilities and advanced radiology equipment (34). Contributions to SDG 15 ("Life on Land") and other goals were under 2%. This indicated that although radiology research was linked to various aspects of sustainable development, its main emphasis remained on health, which is the core domain of radiology. Further details were presented in Table 5.

The distribution showed that radiology research in Indonesia remained heavily centered on clinical and medical aspects, with limited penetration into other areas such as quality education (SDG 4), reduced inequalities (SDG 10), or industrial innovation (SDG 9). This presented an opportunity to broaden the research scope toward more multidisciplinary and integrative approaches, enabling radiology research to contribute not only to health improvement but also to a wider range of sustainable development goals in a holistic manner.

Subsequently, Figure 12 visualized Indonesia's radiology research contributions toward the SDGs, again demonstrating a strong emphasis on SDG 3 as the primary research priority. Key sub-targets such as combating communicable diseases (3.3), reducing mortality from non-communicable diseases (3.4), and strengthening health system capacity and preparedness (3.d) dominated the research, illustrating radiology's vital role in diagnosing,

monitoring, and treating various national health challenges.

Additionally, the research made significant contributions to other SDGs, including technological innovation and health infrastructure development (SDG 9), environmental and conservation issues (SDG 15), and socio-economic concerns such as equitable access to health services and inequality reduction (SDGs 8 and 10). This multidisciplinary approach showed that radiology research in Indonesia integrated clinical, technological, social, and environmental dimensions, aligning with the global sustainable development agenda. Consequently, radiology research played a strategic role in supporting national efforts to comprehensively achieve SDG targets, as further reinforced by Table 6, strengthening the synergy between scientific innovation and inclusive, sustainable socio-economic development.

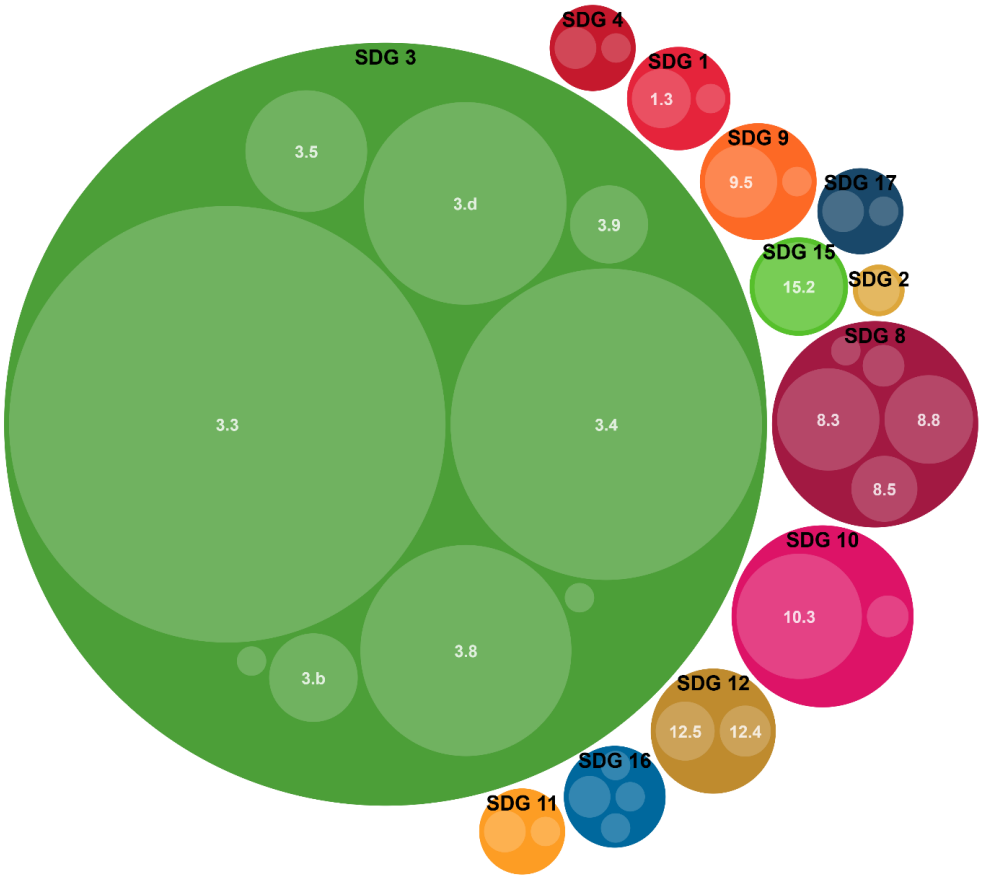

Figure 12. SDGs Target

DISCUSSION

Radiology research in Indonesia related to the Sustainable Development Goals has significantly progressed, with established research trajectories. Beyond its dissemination among international researchers, it has successfully fostered collaborations with numerous foreign experts. In essence, a substantial portion of radiology research in Indonesia involves partnerships with international researchers, reflecting the evolving radiology topics within the country. This progression is also evident in the research metrics, demonstrated by the frequent co-occurrence of various key terms over the past decade (2015-2025), talking examples, such as diagnostic imaging, particularly thorax radiography, has been

extensively explored in medical research due to its critical role in diagnosing and monitoring various health conditions. Studies conducted by Abdullah, et. al (31), Hiswara (45), and Prasetyo (46) emphasize that diagnostic imaging enables clinicians to obtain clear and accurate internal views of patients, facilitating timely and precise clinical decision making.

More specifically, thorax radiography serves as an essential diagnostic tool for assessing pulmonary and cardiac health. Research by Hidayati et al. (47) and Supriyanti et al. (48) highlights the importance of this technique in monitoring lung function and detecting cardiac abnormalities, which can often result from hypertension. Hypertension remains one of the primary risk factors leading to severe cardiac complications such as cardiac enlargement and heart failure. In this context, additional studies by Agustina et. al (30), Majdawati (49), and Pramudita (50) demonstrate that regular thorax radiography in hypertensive patients aids in early detection of organ damage, thereby enabling prompt and effective medical interventions. The relationship between diagnostic imaging and the United Nations Sustainable Development Goals is particularly significant. Firstly, it aligns with SDG3, Good Health and Well-being, by enhancing healthcare quality through faster diagnosis and accurate treatment of cardiovascular diseases including hypertension, a leading cause of global mortality. The application of these technologies helps reduce fatality rates and severe complications, ultimately improving population health outcomes.

Moreover, diagnostic imaging supports SDG9, Industry, Innovation, and Infrastructure, as the advancement and integration of sophisticated medical technologies represent innovation that strengthens healthcare systems. Such infrastructure improvements are vital for developing countries aiming to increase access to high-quality medical services. Additionally, expanding equitable access to diagnostic imaging contributes to Goal Ten, Reduced Inequalities, by diminishing disparities in healthcare availability. Ensuring that underserved and remote communities' benefit from these technologies' fosters inclusivity and equal health opportunities.

Finally, collaborative efforts in research and technology development embody SDG17, Partnerships for the Goals. Cooperation among academic institutions, healthcare providers, governments, and private sectors is essential for advancing medical innovation and achieving sustainable development targets. All in, the use of diagnostic imaging, especially thorax radiography, in diagnosing and managing hypertension is not only critical from a clinical perspective but also significantly advances the achievement of multiple Sustainable Development Goals by promoting inclusive, innovative, and sustainable healthcare.

CONCLUSIONS

This study comprehensively mapped the landscape of radiology research in Indonesia through bibliometric analysis, covering publication productivity, journal sources, authors, affiliations, citations, international collaborations, term networks, and links to the Sustainable Development Goals (SDGs). A significant increase in the number of publications was observed since 2015, although this was not always accompanied by a corresponding rise in scientific impact, as indicated by fluctuating citation counts.

Local journals such as Atom Indonesia dominated the publication sources; however, contributions from reputable international journals reflected an expanding global dissemination. Productive authors like Oscandar F and Dilogo IH were part of collaborative networks connected through central figures such as Yusra. Institutionally,

Universitas Indonesia and Universitas Airlangga led scientific production, while the participation of other institutions demonstrated potential for a more inclusive research ecosystem. International collaborations involved countries across Asia, Europe, and the Americas, strengthening the global network. Terminology analysis revealed thematic diversity and multidisciplinary integration within radiology research. The primary research focus aligned with SDG 3 (Good Health and Well-being), though opportunities remained to expand contributions to other SDGs.

These findings highlighted the importance of improving publication quality, equitable distribution of research capacity, and promoting international publications. By strengthening collaborations and utilizing bibliometric data for strategic planning, Indonesian radiology research had the potential to develop in a more inclusive, innovative, and impactful manner.

This research unveils a substantial conceptual-discursive gap between the output of radiological studies in Indonesia (n=84 documents) and their explicit contribution to the Sustainable Development Goals (SDGs), particularly SDG 3: Good Health and Well-being. Although the studies exhibit a clear conceptual alignment with SDG targets, the lack of explicit SDG-aligned narrative and metric language severely limits the visibility and traceability of the domestic radiology sector's impact on the global development agenda. The study's key contribution, therefore, is to highlight the critical necessity for operationalizing and institutionalizing the SDGs' language within the national radiological discourse to ensure comprehensive recognition and robust metrication of its essential contributions to global health objectives

Nevertheless, the study required methodological expansion. The approach should not have been limited solely to metric reviews and SDG mapping. Future work needed to include more in-depth content analysis of individual articles. Additionally, employing broader databases such as Web of Science and specialized global health indexes would enrich the scope and validity of the findings. Further research direction should also be explored through overlay term analysis to provide deeper insights into dominant issues shaping the focus of radiology research in Indonesia.

APPENDIX

See Table 5 and Table 6.

Table 5. Number of Occurrences of Radiology studies aligned relevant SGDs

SDG	N. OCCURRENCES	% OCCURRENCES
SDG 3	462	83.20%
SDG 8	29	5.20%
SDG 10	20	3.60%
SDG 15	9	1.60%
SDG 9	7	1.30%
SDG 12	7	1.30%

SDG 1	5	0.90%
SDG 16	5	0.90%
SDG 4	3	0.50%
SDG 11	3	0.50%
SDG 17	3	0.50%
SDG 2	2	0.40%

Table 6. Number of Occurrences of Radiology studies aligned SGDs target

SDG	TARGET	N. OCCURRENCES
SDG 1	Target 1.3	4
SDG 1	Target 1.5	1
SDG 2	Target 2.2	2
SDG 3	Target 3.1	1
SDG 3	Target 3.3	218
SDG 3	Target 3.4	111
SDG 3	Target 3.5	17
SDG 3	Target 3.8	51
SDG 3	Target 3.9	7
SDG 3	Target 3.b	9
SDG 3	Target 3.d	47
SDG 3	Other detected terms relevant at goal level	1
SDG 4	Target 4.4	2
SDG 4	Target 4.b	1
SDG 8	Target 8.1	1
SDG 8	Target 8.2	2
SDG 8	Target 8.3	12
SDG 8	Target 8.5	5
SDG 8	Target 8.8	9
SDG 9	Target 9.5	6
SDG 9	Target 9.c	1
SDG 10	Target 10.3	18
SDG 10	Target 10.7	2
SDG 11	Target 11.1	2
SDG 11	Target 11.5	1
SDG 12	Target 12.4	3
SDG 12	Target 12.5	4
SDG 15	Target 15.2	9
SDG 16	Target 16.3	2
SDG 16	Target 16.4	1
SDG 16	Target 16.6	1
SDG 16	Target 16.9	1
SDG 17	Target 17.14	2
SDG 17	Target 17.18	1

ISSN 2548-6462 (online), ISSN 2088-8740 (print)

ACKNOWLEDGEMENTS

I thanks to editors and blind reviewers who reviewed this manuscript. I also to Universitas 'Aisyiyah Yogyakarta, Indonesia who support the publication.

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