



Trends and Innovations in Stunting Prediction Using Machine Learning: A Bibliometric Analysis of Scopus Literature (2019-2024)

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Abstract

Background: Stunting is a global malnutrition issue affecting children's development worldwide. Machine learning (ML) has been applied to predict stunting; however, studies on international collaboration and ML application across various geographical contexts remain limited. **Objective:** This study aims to analyze publication trends and collaboration patterns in stunting prediction research using machine learning and identify the most relevant ML methods. **Methods:** A bibliometric analysis was conducted using the Scopus database, focusing on publications from 2019 to 2024. The data were analyzed through descriptive statistics and science mapping, including trend topics, co-occurrence networks, and international collaboration analysis. **Results:** The study found that regression-based algorithms and deep learning are the most widely used machine learning methods for stunting prediction. International collaborations between countries with high stunting prevalence, such as Indonesia, Bangladesh, and Ethiopia, were also identified. **Conclusion:** This study highlights the importance of developing locally tailored predictive models and strengthening international collaboration to improve the effectiveness of stunting prediction models. Cross-sector and interdisciplinary collaborations are also essential for more holistic solutions.

Keywords: Stunting Prediction; Machine Learning; Bibliometric Analysis.

Introduction

Stunting is a global health issue characterized by impaired child growth due to chronic malnutrition, recurrent infections, and inadequate caregiving practices during early life^{1,2}. This condition results in children having a lower height than the standard for their age, with significant impacts on physical and cognitive development³. In the long term, stunting contributes to reduced economic productivity, increased risk of chronic diseases, and limitations in social development⁴. According to the World Health Organization (WHO), approximately 22% of children under the age of five globally experience stunting⁵.

This condition highlights the importance of prioritizing stunting prevention in public health efforts⁶.

Stunting prediction is a crucial approach to identifying risks and preventing its impacts⁷. This approach utilizes health, nutrition, and socioeconomic data to predict the likelihood of a child experiencing stunting⁸. Early prediction results enable the design of targeted interventions to reduce the prevalence of stunting⁹. This is particularly relevant in developing countries, where stunting rates remain high¹⁰. Thus, stunting prediction represents a strategic step in data-driven prevention efforts¹¹.

Machine learning is a promising technological innovation in stunting prediction¹². This technology can efficiently process complex and diverse data to identify risk patterns often overlooked by conventional approaches¹³. Through machine learning, large-scale data analysis can be performed quickly and accurately¹⁴. The resulting predictive models support data-driven decision-making in stunting prevention¹⁵. This makes machine learning a strategic tool to enhance the effectiveness of interventions in stunting control¹⁶.

Previous studies have demonstrated the use of various machine learning algorithms, such as decision trees, support vector machines (SVM), and deep learning, for predicting stunting^{12,17,18}. These studies utilize data on maternal and child health, socioeconomic conditions, various risk factors, and nutritional patterns. However, many studies face limitations, such as the lack of model generalization across different geographical contexts¹⁹. Additionally, challenges in dataset validation often hinder ensuring prediction accuracy^{20,21,22}. These limitations highlight the need for more comprehensive approaches and more representative data.

Bibliometric analysis is an effective method for evaluating research trends, including stunting prediction using machine learning²³. This study utilized the Scopus database to identify the number of publications, collaboration patterns, leading institutions, and commonly used methods from 2019 to 2024. Scopus was chosen due to its extensive coverage of high-quality scientific literature. Through the bibliometric approach, research can comprehensively reveal trends and patterns in the related field^{24,25,26}. Bibliometric findings can aid in identifying research gaps and potential future collaborations²⁷.

Based on the background explained, stunting is a critical health issue that requires a

predictive approach based on technology to mitigate risks. Machine learning offers significant opportunities to improve prediction accuracy, but there are still research gaps that need to be addressed. Through a bibliometric approach, this study provides a comprehensive overview of research trends in stunting prediction using machine learning. This study uses a descriptive and scientometric mapping approach to answer two research questions. To explore publication trends related to stunting prediction using machine learning (RQ1), descriptive analysis is conducted through annual scientific production, most relevant sources, most relevant authors, most relevant affiliations, country scientific production, and document analysis to understand research growth, author contributions, institutions, and dominant countries. Furthermore, to identify commonly used machine learning methods and their relevance to research outcomes (RQ2), scientometric mapping is conducted through trend topics, co-occurrence networks, thematic maps, three-field plots, and collaboration networks. This approach provides comprehensive insights into research themes, relationships between concepts, and collaboration patterns among researchers, institutions, and countries, thus mapping the development and key contributions in this field of research.

Materials and Methods

Study Design

This study uses a bibliometric approach to analyze publications related to stunting prediction using machine learning. Bibliometrics is a quantitative method used to evaluate and visualize research patterns based on metadata from scientific publications^{28,29}. The bibliometric approach was chosen for its ability to provide deep insights into research trends, researcher collaborations, and methodologies used. The goal of using

bibliometrics is to identify key trends, commonly used methods, and potential research gaps in the studied topic³⁰.

Sample

The "sample" in this normative study consists of primary and secondary legal materials. The primary legal materials are the core objects of analysis and include: (1) Law No. 36 of 2009 on Health; (2) Law No. 17 of 2023 on Health; and (3) relevant articles of the Indonesian Criminal Code (KUHP). Secondary legal materials provide context, theoretical support, and scholarly interpretation. These include legal textbooks on health law and malpractice^{10,11}, articles from law and medical journals^{4,7,8}, and scholarly commentaries on the new law.

Data Collection Technique

The research data was retrieved from the Scopus database, one of the largest bibliographic platforms with extensive coverage of high-quality scientific journals. The search query used was ("stunting" AND "machine learning" AND "prediction"), specifically targeting publications from 2019 to 2024. This time frame was chosen to focus on the most recent developments in the field. The search was conducted across the title, abstract, and keywords of the publications to ensure that the results were highly relevant to the research topic. By including these fields, the search aimed to capture a broad range of relevant articles that specifically address the application of machine learning in predicting stunting, ensuring that the findings accurately reflect current trends in the field.

Data Analysis Technique

The data analysis in this study was conducted using various tools to provide a comprehensive overview of research trends, methods used, and collaboration patterns in the topic of stunting prediction using machine learning. VoS Viewer

was used to visualize the relationships and networks between authors, institutions, and keywords, while OpenRefine ensured the data was clean and organized. Advanced bibliometric analysis, including trend analysis, author collaboration, and representation of main topics, was conducted using RStudio with Biblioshiny. Microsoft Excel was used for additional descriptive analysis, including the number of publications per year. The analysis process involved importing the validated data into each tool, configuring parameters as needed, and generating visual and statistical outputs for further interpretation.

Ethical Consideration

This study used a bibliometric approach based on publication metadata retrieved from the Scopus database and did not involve direct human participants, clinical intervention, biological samples, or identifiable personal data. All analyzed data were obtained from publicly indexed scientific publications, including titles, abstracts, keywords, author information, affiliations, citations, and publication sources. Therefore, formal ethical approval and informed consent were not required. Nevertheless, the study was conducted according to principles of research integrity, transparency, and academic ethics. All sources were properly acknowledged, data were analyzed objectively, and findings were reported accurately without manipulating bibliometric results or misrepresenting authors, institutions, countries, or their scientific contributions within the reviewed literature.

Results

In this section, we present the research findings obtained through bibliometric analysis related to stunting prediction using machine learning. This analysis includes trends in publication development, relevant sources, dominant authors and affiliations, as well as collaboration

patterns among authors and institutions across various countries. Using various analytical tools such as VoS Viewer, OpenRefine, RStudio with Biblioshiny, and Microsoft Excel, the results provide deep insights into the

dynamics of research in this field. Subsequently, we present these findings in both descriptive and visual formats to facilitate understanding of the main findings relevant to the objectives of this study.

Table 1. Main information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2019:2024
Sources (Journals, Books, etc)	25
Documents	34
Annual Growth Rate %	69,52
Document Average Age	1,15
Average citations per doc	8,029
References	1288
DOCUMENT CONTENTS	
Keywords Plus (ID)	382
Author's Keywords (DE)	91
AUTHORS	
Authors	181
Authors of single-authored docs	0
AUTHORS COLLABORATION	
Single-authored docs	0
Co-Authors per Doc	5,44
International co-authorships %	32,35
DOCUMENT TYPES	
article	21
book chapter	1
conference paper	11
conference review	1

Table 1, titled "Main Information," presents key information regarding publications related to stunting prediction using machine learning from 2019 to 2024. During this period, 34 documents were published from 25 sources, with an annual growth rate of 69.52%. The average age of the documents is 1.15 years, indicating relatively recent research, with an average of 8.029 citations per document. A total of 1,288 references were recorded. In terms of document content, there

are 382 additional keywords (Keywords Plus) and 91 author's keywords. The research involves 181 authors, with no documents authored by a single writer. Author collaboration also shows an average of 5.44 co-authors per document, with 32.35% of collaborations being international. The document types consist of 21 articles, 1 book chapter, 11 conference papers, and 1 conference review.

Table 2: Integrated Summary of Most Relevant Sources, Authors, Affiliations, and Countries in Stunting Prediction Research (2019–2024)

Category	Subcategory	Details	Count/Fraction
Most Relevant Sources	PLOS ONE	Articles	5
	ICODSA 2024	Articles	3
	CHILDREN	Articles	3
	AIMS 2024	Articles	2
	DELCON 2022	Articles	1
	ISEMANTIC 2022	Articles	1
	AIP CONFERENCE PROCEEDINGS	Articles	1
	BMC MEDICAL INFORMATICS AND DECISION MAKING	Articles	1
	BMC NUTRITION	Articles	1
	BULLETIN OF ELECTRICAL ENGINEERING AND INFORMATICS	Articles	1
	Most Relevant Authors	GUNAWAN PH	Articles
INDWIARTI		Articles	2 (0.67 fractionalized)
KABANO IH		Articles	2 (0.42 fractionalized)
USMAN M		Articles	2 (0.70 fractionalized)
ABEDI AJ		Articles	1 (0.25 fractionalized)
ABEDIN MM		Articles	1 (0.14 fractionalized)
ABU AL-HALAWA D		Articles	1 (0.08 fractionalized)
AGIMAS MC		Articles	1 (0.14 fractionalized)
AHAMMED B		Articles	1 (0.14 fractionalized)
AHMED NAMF		Articles	1 (0.14 fractionalized)
Most Relevant Affiliations	UNIVERSITY OF RWANDA	Articles	10
	SATYA WACANA CHRISTIAN UNIVERSITY	Articles	9
	TELKOM UNIVERSITY	Articles	8
	KEMRI-CGHR	Articles	7
	UNIVERSITY OF GONDAR	Articles	7
	WIDYA MANDALA SURABAYA CATHOLIC UNIVERSITY	Articles	7
	COLGATE UNIVERSITY	Articles	6
	GUANGZHOU MEDICAL UNIVERSITY	Articles	6
	KHULNA UNIVERSITY	Articles	6
	BINA NUSANTARA UNIVERSITY	Articles	5
Countries' Scientific Production	INDONESIA	Frequency	50
	USA	Frequency	20
	BANGLADESH	Frequency	14
	INDIA	Frequency	12
	CHINA	Frequency	11
	ETHIOPIA	Frequency	11
	RWANDA	Frequency	11
	CANADA	Frequency	7
	KENYA	Frequency	7
ZAMBIA	Frequency	6	

Table 2, titled "Integrated Summary of Most Relevant Sources, Authors, Affiliations, and Countries in Stunting Prediction Research (2019–2024)" provides a comprehensive overview of key contributors to the field of stunting prediction using machine learning. The table highlights that PLOS ONE ranks as the most significant source with five articles, followed by notable international conferences such as the 2024 International Conference on Data Science and Its Applications (ICODSA 2024) and the International Conference on Artificial Intelligence and Mechatronics System (AIMS 2024), which contributed three and two articles, respectively. Other important sources include specialized journals like Children, BMC Medical Informatics and Decision Making, and BMC Nutrition, alongside prominent conference proceedings such as the AIP Conference Proceedings and the 2022 IEEE Delhi Section Conference (DELCON 2022). In terms of authors, Gunawan PH, Indwiarti, Kabano IH, and Usman M emerged as the most productive researchers, each contributing two articles. Among them, Usman M had the highest

fractionalized contribution (0.70), reflecting a leading role in their collaborative works. Affiliations from across the globe are well-represented, with the University of Rwanda leading with 10 articles, followed closely by Satya Wacana Christian University (9 articles) and Telkom University (8 articles). Other institutions like the Kenya Medical Research Institute-Center for Global Health Research (KEMRI-CGHR), University of Gondar, and Widya Mandala Surabaya Catholic University contributed significantly with 7 articles each, emphasizing the pivotal role of institutions from developing regions. Furthermore, the table underscores the geographical distribution of research efforts, with Indonesia dominating the field with 50 publications, followed by the USA (20 articles) and other developing countries such as Bangladesh (14), India (12), China, Ethiopia, and Rwanda (each 11 articles). This global pattern reflects the critical focus on stunting as a public health issue, particularly in developing nations, complemented by the involvement of developed countries leveraging technology-based approaches to address this challenge.

Table 3. Trend Topics

Term	Frequency	Year (Q1)	Year (Median)	Year (Q3)
wasting syndrome	7	2021	2021	2022
bangladesh	6	2021	2021	2023
malnutrition	24	2022	2022	2024
underweight	10	2021	2022	2024
prevalence	8	2022	2022	2024
machine learning	38	2022	2023	2024
female	25	2022	2023	2024
child	22	2022	2023	2024
male	21	2022	2024	2024
algorithm	12	2023	2024	2024

Table 3, "Trend Topics," shows the keywords frequently appearing in research on stunting prediction using machine learning from 2019 to 2024, along with the temporal distribution of their usage. The term "machine

learning" has the highest frequency (38) and became dominant from 2022 to 2024, reflecting the relevance of this technology in the health field. Keywords such as "female" (25), "child" (22), and "male" (21) indicate a focus on key

demographic groups. Health condition-related themes such as "malnutrition" (24), "underweight" (10), and "wasting syndrome" (7) also appear consistently, showing the close connection between stunting and other malnutrition factors. Additionally, technical terms like "algorithm" (12) became more

prominent in recent years (median 2024), highlighting the growing attention to the development of methodological approaches. Overall, these trends reflect the evolving focus of research, from identifying issues to applying advanced technology for predictive solutions.

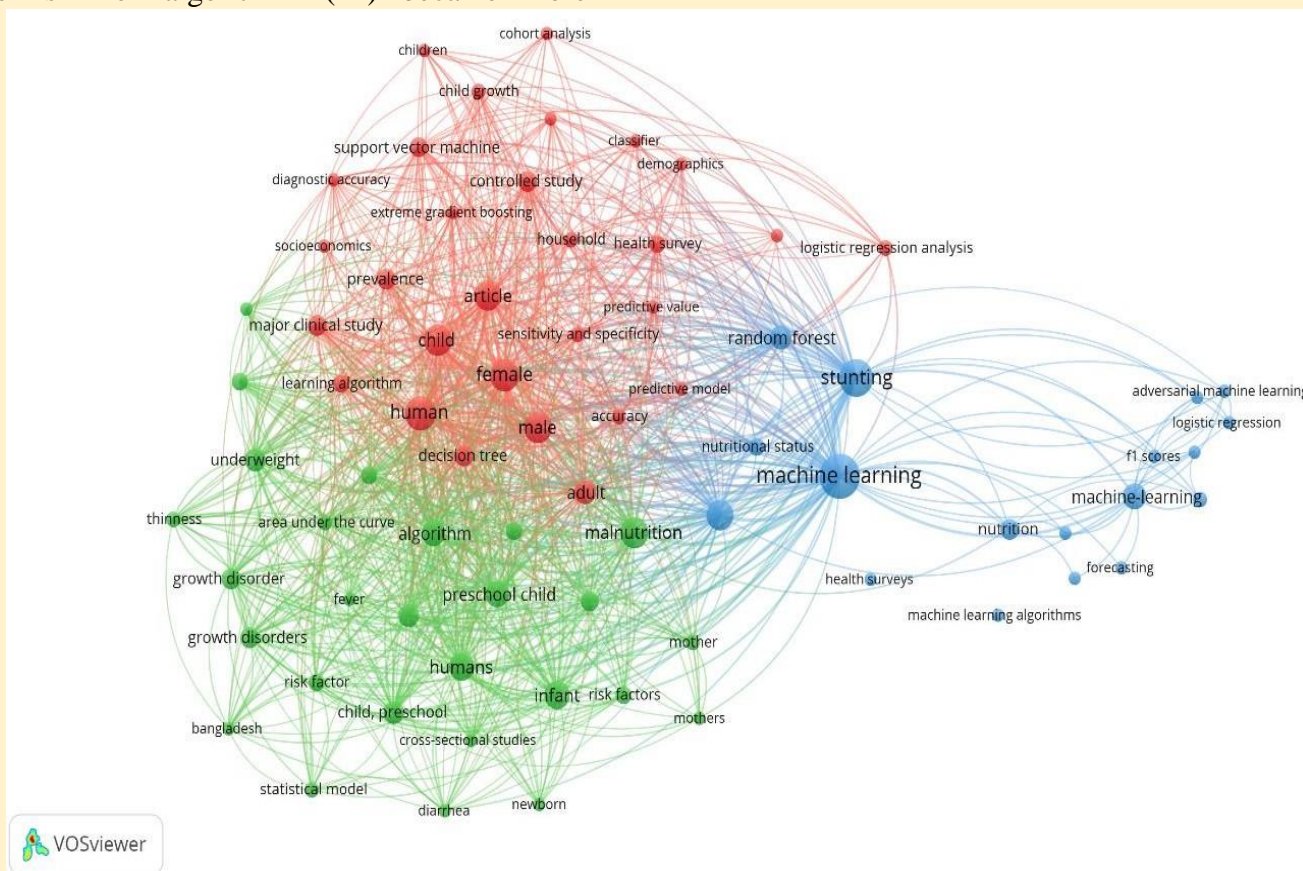


Figure 1. Co-Occurrence Network

Figure 1, "Co-occurrence Network," shows the relationships between keywords that frequently appear together in research on stunting prediction using machine learning. All keywords are grouped into one cluster, indicating a focused topic with strong interconnections. The term "human" has the highest betweenness value (38.368), reflecting its crucial role in connecting key concepts in the research. Other keywords such as "female" (33.372), "male" (29.272), and "child" (26.03) also have significant betweenness values, indicating their relevance in discussing aspects of the research target population. The closeness of all keywords ranges from 0.018 to 0.019,

reflecting a uniform level of interconnectedness within the network. The highest PageRank value is held by "human" (0.045), followed by "female" (0.042) and "male" (0.04), which highlights the importance of these terms within the overall network structure. Overall, this analysis illustrates that the research is highly focused on the human population, especially children, with particular attention to gender and nutrition.

Figure 2, "Thematic Map," illustrates the main topics of research, focusing on cohort analysis, which is the core of cluster 1. Terms such as "cohort analysis," "childhood," "economic aspect," and "follow up" have high

betweenness centrality, with "cohort analysis" achieving the highest value (241.108). This indicates the key role of this topic in connecting various concepts in stunting-related research. Other terms like "short stature" (96.619) and "outcome assessment" (90.336) also show significant relevance in this analysis. All terms within the cluster have uniform closeness values (0.002), reflecting tight interconnections

within the cluster. The highest PageRank value is found for "cohort analysis" (0.005), emphasizing its position as the central topic. Overall, this analysis highlights cohort-based approaches as the central theme in the research, focusing on health, socioeconomic factors, and outcome measurements relevant for understanding stunting.



Figure 2. Thematic Map

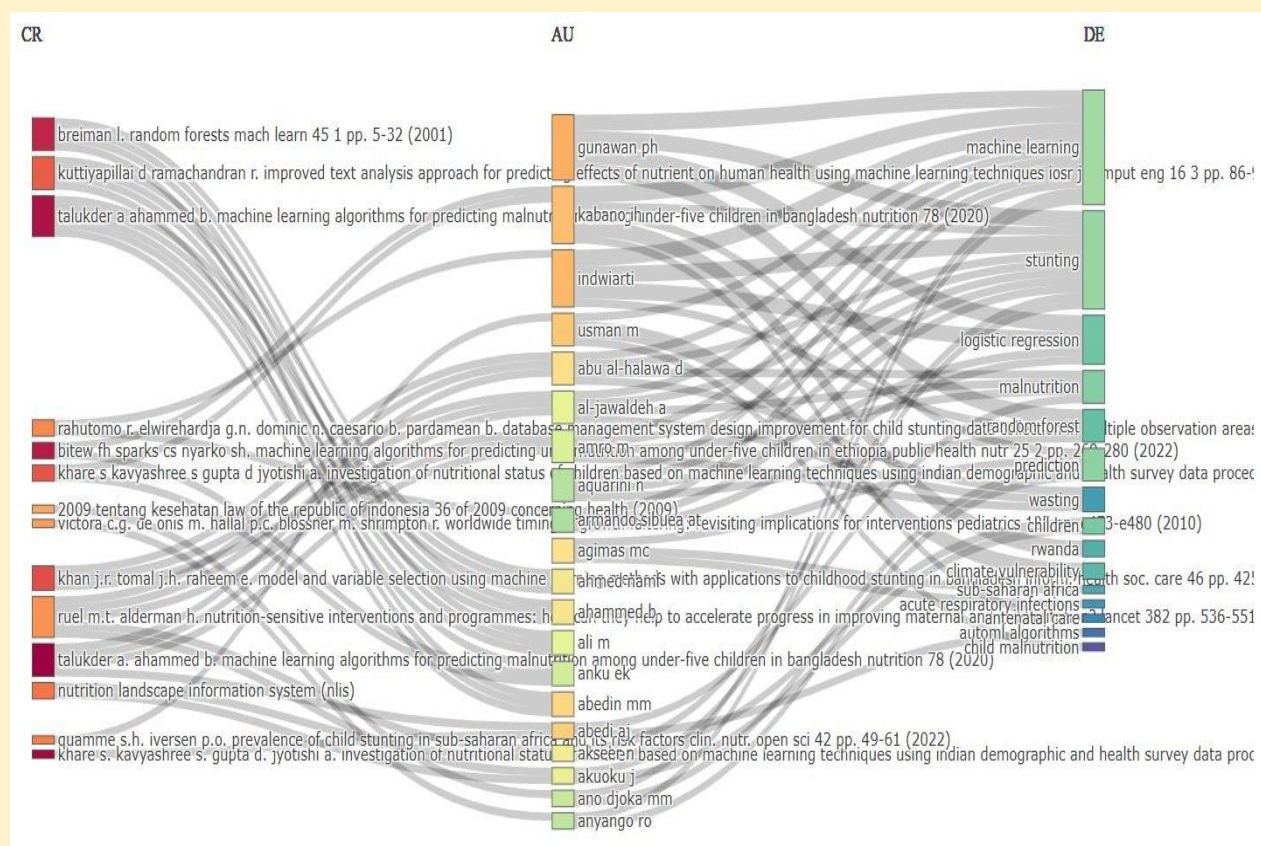


Figure 3. Three Field Plot

Figure 3, "The Three Field Plot," illustrates the intricate relationships among authors, institutions, and research topics in the field of stunting prediction using machine learning. This visualization provides a comprehensive view of how these elements interact to shape the research landscape. The horizontal axis showcases the most productive authors, such as Gunawan PH and Indwiarti, while the vertical axis highlights the institutions significantly contributing to the field, including the University of Rwanda and Satya Wacana Christian University. The third column emphasizes the most frequently occurring research topics or keywords, such as "malnutrition," "machine learning," and "childhood," which define the primary focus

areas of the studies. The plot reveals collaboration patterns where the proximity of authors to institutions reflects their level of interaction in publishing research, and the prominence of specific topics at the top indicates their centrality in the field. For instance, authors like Gunawan PH are closely associated with multiple institutions and frequently discussed topics, indicating a strategic role in bridging collaborations and advancing research. This interconnected view of authors, institutions, and topics not only highlights the collaborative networks but also sheds light on emerging trends and dominant areas of interest in stunting prediction research, offering valuable insights into the development and dissemination of knowledge in this domain.

Discussion

Descriptive Analysis of Publication Trends in Research on Stunting Prediction Using Machine Learning

In this study, a descriptive analysis was conducted to illustrate the publication trends in the field of stunting prediction using machine learning from 2019 to 2024. The findings indicate a significant increase in the annual number of publications, with an Annual Growth Rate of 69.52%. This demonstrates that the topic of stunting prediction through machine learning technology is gaining increasing attention within the scientific community. The growth reflects the rising number of researchers focusing on the application of advanced technology to address the global issue of stunting, particularly in developing countries. The increasing focus on advanced technologies in research is essential to better identify risk factors and mitigate the impacts of stunting more effectively.

In addition, the results show that over the past five years, PLOS ONE has been the journal with the highest number of publications related to stunting prediction using machine learning, with 5 publications. This journal is recognized as one of the leading multidisciplinary journals with a significant impact across various research fields, including health sciences and technology. Other outlets, such as the 2024 International Conference on Data Science and its Applications (ICODSA 2024) and Children, also emerged as highly relevant sources, each with 3 publications. The utilization of these diverse sources indicates that research on stunting prediction using machine learning is not only published in scientific journals but is also actively presented at conferences and scientific forums, reflecting the growing interest in this topic.

Speaking of authors, data analysis reveals that authors such as Gunawan PH, Indwiarti,

and Usman M each have two publications during this period, making significant contributions to the field. This suggests that these authors may be key players in advancing research on stunting prediction using machine learning. Other authors, while contributing less frequently, still play a role in enriching insights into new ways to predict and address stunting. Authors with greater contributions can be seen as leaders in this research area, likely facilitating significant progress in the field.

In terms of affiliations, the analysis found that institutions such as the University of Rwanda, Satya Wacana Christian University, and Telkom University have made a notable number of publications related to this topic. These universities have played a pivotal role in advancing research in the field, whether through teaching, research, or international collaborations. These institutions demonstrate a commitment to addressing the issue of stunting, which is likely relevant to their geographical contexts. For example, the University of Rwanda, with 10 publications, reflects its strong engagement in public health research, particularly in the context of developing countries facing high stunting rates.

The country most actively publishing research on stunting prediction using machine learning is Indonesia, with 50 publications, reflecting the high level of attention to the stunting issue in the country. This research focus may be influenced by the fact that Indonesia is one of the countries with the highest stunting rates globally, prompting extensive studies aimed at finding solutions to the problem. Other countries, such as the USA, Bangladesh, and India, also demonstrate significant contributions, with 20, 14, and 12 publications, respectively, highlighting the presence of international collaboration in this research area. This supports the notion that stunting is a global challenge requiring cross-country cooperation.

The findings of this study indicate a strong trend in the use of machine learning for predicting stunting, with techniques such as algorithms and predictive analysis being increasingly applied. This also demonstrates that the field is advancing, with various disciplines collaborating to identify stunting risk factors more accurately and efficiently. The application of machine learning in healthcare, particularly in stunting prediction, represents a significant step forward, enabling earlier identification of children at risk of stunting³³. This research shows that by utilizing more complex health and socioeconomic data, machine learning can provide deeper insights and more effective solutions to reduce the prevalence of stunting in the future.

Science Mapping in Research on Stunting Prediction Using Machine Learning

In the first part of the science mapping analysis, *Trend Topics* highlight significant developments in topics related to stunting prediction using machine learning. One of the most frequently appearing topics is *malnutrition*, with an occurrence frequency of 24, indicating that poor nutrition remains a primary focus in stunting research. This frequency has further increased between 2022 and 2024, reflecting a growing global awareness of the nutritional challenges associated with stunting. In this context, *malnutrition* is often identified as a key determinant in stunting studies³⁴, particularly in the realm of data-driven predictive technology³⁵. Similarly, related topics such as *underweight*, *prevalence*, and *wasting syndrome* have seen increased discussion since 2021. This rise can be attributed to a heightened focus on leveraging new technologies to address stunting issues effectively.

Moreover, the *Co-occurrence Network* analysis provides significant insights into the

relationships between frequently appearing keywords in related publications. In this context, keywords such as *female*, *male*, *child*, and *human* highlight that stunting affects highly specific groups, particularly children and differences across genders. The close connections among these keywords indicate that gender differences and age groups are crucial factors to consider in stunting prediction models. Research by Usman M and Kopczevska K. (2022) demonstrates that gender and age group differences can influence the prevalence of stunting⁷, which is also reflected in this data. On the other hand, keywords such as *algorithm* and *machine learning* underscore that advanced technologies, particularly machine learning-based algorithms, are integral to modeling and prediction efforts.

The *Thematic Map* reinforces this understanding by identifying the relationships between the main themes emerging in this research. Keywords such as *cohort analysis*, *childhood*, and *economic aspect* appear in clusters related to long-term analyses focusing on factors influencing stunting. Cohort analysis is crucial as it provides insights into the impact of socioeconomic factors on child development, including stunting, over time. Research by Nur AF et al. (2023) supports the idea that economic factors, such as poverty and inequality, significantly contribute to the prevalence of stunting in children³⁶. This is reflected in the frequent co-occurrence of topics like *poverty* and *economic aspect* with keywords such as *childhood*.

The *Three-Field Plot* provides a deeper visual analysis of the relationships between keywords, authors, and affiliations³⁷. This plot reveals strong collaboration among authors from various institutions, highlighting the importance of teamwork in developing solutions to the issue of stunting. The involvement of affiliations from multiple

countries, such as Indonesia, Ethiopia, and Rwanda, demonstrates that this research is global in nature and engages international actors in efforts to address stunting. Authors from these institutions, such as the University of Rwanda and Satya Wacana Christian University, have made significant contributions to the discourse on stunting, reflecting their commitment to tackling the issue both locally and globally.

In the aspect of the *Collaboration Network*, the research findings show close collaboration between high-connectivity authors such as Gunawan PH, Indwiarti, and Usman M, who focus on topics like malnutrition and machine learning. This collaboration has led to the development of increasingly complex prediction models for stunting, utilizing machine learning techniques that have the potential to improve prediction accuracy. Research by Fu et al. (2022) demonstrates that international collaboration can enhance the quality and innovation in research³⁸, which is clearly evident in this collaboration network. These authors, despite coming from diverse backgrounds, play a crucial role in developing methodologies that are more effective in identifying and addressing stunting.

Finally, the overall results of the Science Mapping illustrate how advanced technologies, particularly machine learning, are increasingly being applied to address the issue of stunting. The rising trend of topics, collaboration among authors, and involvement of various countries in this research indicate that stunting has become a highly relevant issue worldwide. This research aligns with the findings mentioned by Pratama et al. (2024) and Kirk et al. (2022), who stated that by using larger datasets and algorithm-based models, stunting prediction and prevention can be carried out more accurately and efficiently^{39,40}. Therefore, this science mapping provides a better understanding of how this research is evolving

and how new machine learning techniques play a role in reducing the global prevalence of stunting.

Conclusion

This study provides deep insights into the trends and developments in research related to stunting using machine learning-based predictive techniques. The analysis results show that topics related to malnutrition, childhood, and machine learning have seen a significant increase in scholarly publications from 2021 to 2024, reflecting a greater focus on the challenges of malnutrition and the application of advanced technologies to address this issue. It was also found that there is close collaboration among authors from various countries, with affiliations involving leading institutions from Indonesia, Rwanda, and Ethiopia, indicating that research on stunting is global and involves cross-country collaborative efforts. The results from the Co-occurrence Network and Thematic Map emphasize that socioeconomic factors and data-driven approaches are crucial in stunting analysis, with attention to gender and age group differences as key variables in prediction.

Although this study provides important insights into the use of machine learning in stunting prediction, there are still several gaps that need to be explored further. Future research could focus on developing more specific predictive models that take into account local characteristics and socioeconomic factors that differ across countries. Additionally, more intensive collaboration between countries with high stunting prevalence, such as Indonesia, Bangladesh, and Ethiopia, as well as the health and public policy sectors, is needed to create a shared data platform that can improve the accuracy of predictive models. Interdisciplinary studies involving social sciences, public health, and technology are also

important to produce holistic solutions that are not only medically based but also include sustainable social and economic policies.

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Conflict of Interest Statement

The author(s) declare no commercial, financial, or personal conflicts of interest related to this research. All authors approved the final manuscript and consented to its publication in *Healthy Tadulako Journal*.

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