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GLOBAL RESEARCH TRENDS IN MACHINE LEARNING–BASED PREDICTION OF ADOLESCENT CONTRACEPTIVE USE: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Adolescent contraceptive use remains a major global reproductive health issue because of its association with unintended pregnancy, unsafe abortion, maternal mortality, and long-term psychosocial consequences, particularly in low- and middle-income countries (LMICs). Although machine learning has been increasingly applied in reproductive health prediction, the global development and intellectual structure of this research field remain insufficiently defined. Bibliometric and science mapping analyses were conducted using the Scopus and Web of Science databases, covering publications from 1986 to 2026. Searches performed on May 4, 2026, identified 536 records that were screened. After deduplication and a structured bibliographic selection workflow guided by PRISMA flow principles, 193 English-language articles and conference papers were included in the analysis. PRISMA principles were used solely to improve transparency in the document selection process, rather than to perform a formal systematic review or evidence synthesis. Analyses were conducted using Bibliometrix (R/RStudio), VOSviewer, and Microsoft Excel to evaluate publication trends, research life cycle, Bradford's Law, scientific productivity, keyword co-occurrence, thematic mapping, and thematic evolution. Publication output increased markedly after 2010 and is expected to peak in 2025 (n=36). Life-cycle analysis predicted continued growth, with a projected publication peak around 2043.4 (R^2=0.701). The Journal of Adolescent Health and PLOS ONE were the leading journals. The United States showed the highest scientific production (n=54), while Tehran University of Medical Sciences was the most productive institution (n=42). Emerging themes include machine learning, random forests and predictive analytics. The field is rapidly evolving toward AI-driven reproductive health prediction, highlighting the opportunities for ethical, explainable, and data-driven contraceptive decision support systems.

KEYWORDS: Adolescent, Contraceptive Use, Machine Learning, Reproductive Health.

1. INTRODUCTION

Contraceptive use among adolescents is a priority issue in global reproductive health because it is closely linked to unintended pregnancies, unsafe abortions, maternal mortality, school dropouts, intergenerational poverty, and a range of long-term psychosocial and health effects [1]. Adolescents are in a complex phase of biological, psychological, and social transition; therefore, decisions regarding contraceptive use are influenced by multiple multidimensional factors, such as education, economic status, access to health services, cultural norms, reproductive health knowledge, and support from family and the social environment [2,3]. Therefore, predicting contraceptive use among adolescents is crucial for supporting targeted, evidence-based reproductive health interventions.

Globally, the burden of adolescent pregnancy remains high, particularly in low- and middle-income countries (LMICs). The World Health Organization (WHO) reports that approximately 21 million adolescent girls aged 15–19 become pregnant each year, and about 50% of these pregnancies are unintended [4]. Furthermore, UNICEF reported that approximately 13% of young women worldwide had given birth before the age of 18 in 2023 [5]. The high rate of adolescent pregnancy indicates that the use of modern contraceptives among adolescents remains suboptimal and poses a major challenge to achieving the Sustainable Development Goals (SDGs), especially in relation to reproductive health targets and the reduction of adolescent birth rates.

Adolescent reproductive health issues are a serious concern in Indonesia. The National Population and Family Planning Board (BKKBN) emphasizes that increasing the modern contraceptive prevalence rate (mCPR) and reducing unmet need for family planning are national priorities in the BKKBN Strategic Plan 2020–2024 [6]. Nonetheless, the unmet need for family planning in Indonesia remained at 11.5% in 2023, higher than the RPJMN target of 7.4% [7]. Additionally, the fertility rate among Indonesian adolescent girls aged 15–19 years is approximately 26.6 per 1,000 women of reproductive age, indicating that adolescent pregnancy remains a national public health challenge [8]. Previous studies have also shown that the use of modern contraceptives among adolescents and young women in Indonesia remains relatively low and is influenced by education, socioeconomic factors, access to health services, and cultural and religious norms [9]. In recent decades, research on adolescent contraceptive use has evolved from conventional epidemiological approaches to artificial intelligence and machine learning-based methods.

Earlier studies have generally focused on identifying factors associated with contraceptive use, such as education, age, knowledge, marital status, socioeconomic status, access to health services, and cultural factors. However, traditional statistical approaches often have limitations in capturing the nonlinear relationships and complex interactions between variables that influence contraceptive use. Developments in machine learning, such as decision trees, random forests, deep learning, neural networks, and predictive analytics, offer new opportunities for building more accurate and adaptive predictive models of reproductive health behavior [10–12]. Some empirical studies have shown that machine learning algorithms perform better than conventional statistical approaches in predicting contraceptive use behavior and adolescent pregnancy risk. However, most of these studies are limited to specific populations and countries or focus solely on model development without evaluating the progression of scientific knowledge. Previous studies have also mostly emphasized algorithm performance and prediction accuracy over mapping the research landscape, trends in scientific development, research collaboration, thematic structures, and the evolution of research topics.

Based on these conditions, there is a clear research gap, namely the absence of a comprehensive bibliometric study that specifically maps the global development of research on machine learning-based prediction of adolescent contraceptive use over the past four decades. Bibliometric mapping is crucial for understanding the direction of research development, publication trends, core journals, the most influential authors and affiliations, networks of scientific collaboration, and emerging research themes.

The novelty of this study lies in its global bibliometric analysis, which specifically evaluates research trends regarding machine learning–based prediction of adolescent contraceptive use during the period 1986–2026. Unlike previous studies that focused only on model evaluation or the determinants of contraceptive use, this study comprehensively mapped the development of the field through an analysis of annual scientific production, research life cycle, Bradford's Law, author and affiliation productivity, country analysis, trend topics, co-occurrence keywords, thematic map, and thematic evolution. This study used the Scopus and Web of Science databases, with a final total of 193 documents that met the inclusion criteria for analysis.

Theoretically, this research is supported by socio-ecological theory and a data-driven decision-making approach. Socio-Ecological Theory explains that adolescent contraceptive behavior is influenced by the interaction of individual, interpersonal, community, institutional, and health policy factors [13,14]. The data-driven decision-making approach emphasizes the importance of using big data and predictive analytics to support more precise and effective public health decision-making [15,16]. In this context, machine learning is a relevant approach for identifying hidden patterns, predicting contraceptive behavior, and supporting the development of evidence-based reproductive health interventions.

This study aimed to analyze global research trends in the machine learning-based prediction of adolescent contraceptive use through a bibliometric approach. Specifically, it seeks to identify the growth of annual scientific publications, analyze research development cycles, identify core journals based on Bradford's Law, map the most productive authors, affiliations, and countries, analyze keyword trends and the conceptual structure of the research, and evaluate the evolution of research themes over the period 1986–2026. As this is a bibliometric study, it does not test the causal hypotheses. However, this study is based on the assumption that machine learning research for predicting adolescent contraceptive use has experienced significant growth in the last decade, in line with advances in artificial intelligence, big health data, and the need for more accurate data-driven reproductive health-prediction systems.

1.1. Research Questions

This study was designed to examine the Global Research Trends in Machine Learning-Based Prediction of Contraceptive Use among adolescents over four decades as follows:

RQ1: How has the annual scientific output and citations on Machine Learning-Based Prediction of Contraceptive Use among adolescents grown?

RQ2: What is the development cycle (research life cycle) of annual scientific publications on Machine Learning-Based Prediction of Contraceptive Use among adolescents?

RQ3: What are the core journal sources based on Bradford's Law regarding Machine Learning-Based Prediction of Contraceptive Use among adolescents?

RQ4: Who are the most relevant authors and affiliations, and what are the impacts of Machine Learning-Based Prediction of Contraceptive Use among adolescents?

RQ5: Which country's scientific production concerns Machine Learning-Based Prediction of Contraceptive Use among adolescents?

RQ6: What are the trending topics regarding Machine Learning-Based Prediction of Contraceptive Use among adolescents?

RQ7: What co-occurrence networks exist regarding ML-based prediction of contraceptive use among adolescents?

RQ8: What is the thematic structure and evolution of research on Machine Learning-Based Prediction of Contraceptive Use among adolescents?

2. METHODS

2.1. Study Design

This study employed a bibliometric and science mapping approach, a quantitative method widely used to evaluate scientific development, publication trends, collaboration patterns, intellectual structures, and thematic evolution in research fields [17]. Unlike conventional systematic reviews or meta-analyses that synthesize clinical evidence, bibliometric analyses focus on mapping scientific production, conceptual structures, citation relationships and research dynamics over time.

This study adopted a structured bibliographic selection workflow guided by the PRISMA flow principles, consisting of four stages: identification, screening, eligibility, and inclusion (Figure 1) [18]. PRISMA principles were used to improve transparency in the document selection process; however, this study was not designed as a formal systematic review or a meta-analysis. Therefore, no clinical evidence synthesis, risk of bias assessment, or meta-analytic pooling was performed.

The primary objective of this study was to map the global scientific landscape of machine learning–based prediction of contraceptive use among adolescents, including publication trends, intellectual structures, scientific productivity, keyword patterns, co-occurrence networks, and thematic evolution. This bibliometric approach was considered appropriate because it allowed us to identify how reproductive health research has shifted from conventional epidemiological analysis to data-driven and machine learning–based predictive approaches.

To ensure broad and high-quality bibliographic coverage, this study used two internationally recognized scientific databases, Scopus and the Web of Science (WoS). These databases were selected

because of their extensive multidisciplinary journal coverage, high indexing quality, citation metadata completeness, and compatibility with bibliometric software tools such as Bibliometrix and VOSviewer. Nevertheless, this study acknowledges certain limitations, including the exclusion of other databases, such as PubMed, Dimensions, and Google Scholar, which may affect the generalizability and comprehensiveness of its findings.

2.2. Data Collection

Bibliographic data were retrieved from Scopus (n = 446 documents) and Web of Science (WoS) (n = 90 documents) databases, resulting in an initial total of 536 records. The search was conducted on May 4, 2026, and covered publications published between 1986 and 2026. The search strategy was developed using Boolean operators, truncation terms, and combinations of English keywords related to adolescents, contraceptive use, reproductive health behavior, and machine learning. Searches were performed within the title, abstract, and keyword fields to maximize retrieval sensitivity and thematic relevance.

The Scopus search syntax was as follows: TITLE-ABS-KEY(("adolescent" OR "teen*" OR "youth" OR "young women" OR "female adolescent*") AND ("contraceptive use" OR "contraception" OR "family planning" OR "birth control" OR "contraceptive uptake" OR "modern contraceptive*") AND ("machine learning" OR "artificial intelligence" OR "deep learning" OR "predictive model*" OR "classification" OR "data mining" OR "neural network*" OR "random forest" OR "decision tree")). Equivalent keyword structures and Boolean combinations were adapted for the Web of Science database.

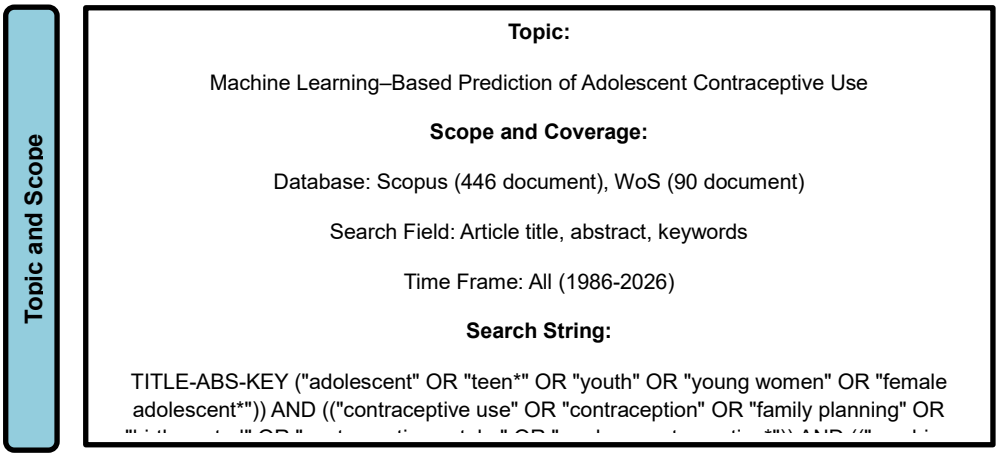
The inclusion criteria were as follows: (1) publications written in English; (2) original research articles and conference papers; (3) publications at the final publication stage; (4) documents available in full text; and (5) studies relevant to machine learning, artificial intelligence, predictive modelling, classification, data mining, or related computational approaches in contraceptive use, adolescent reproductive health, family planning, or reproductive health behavior.

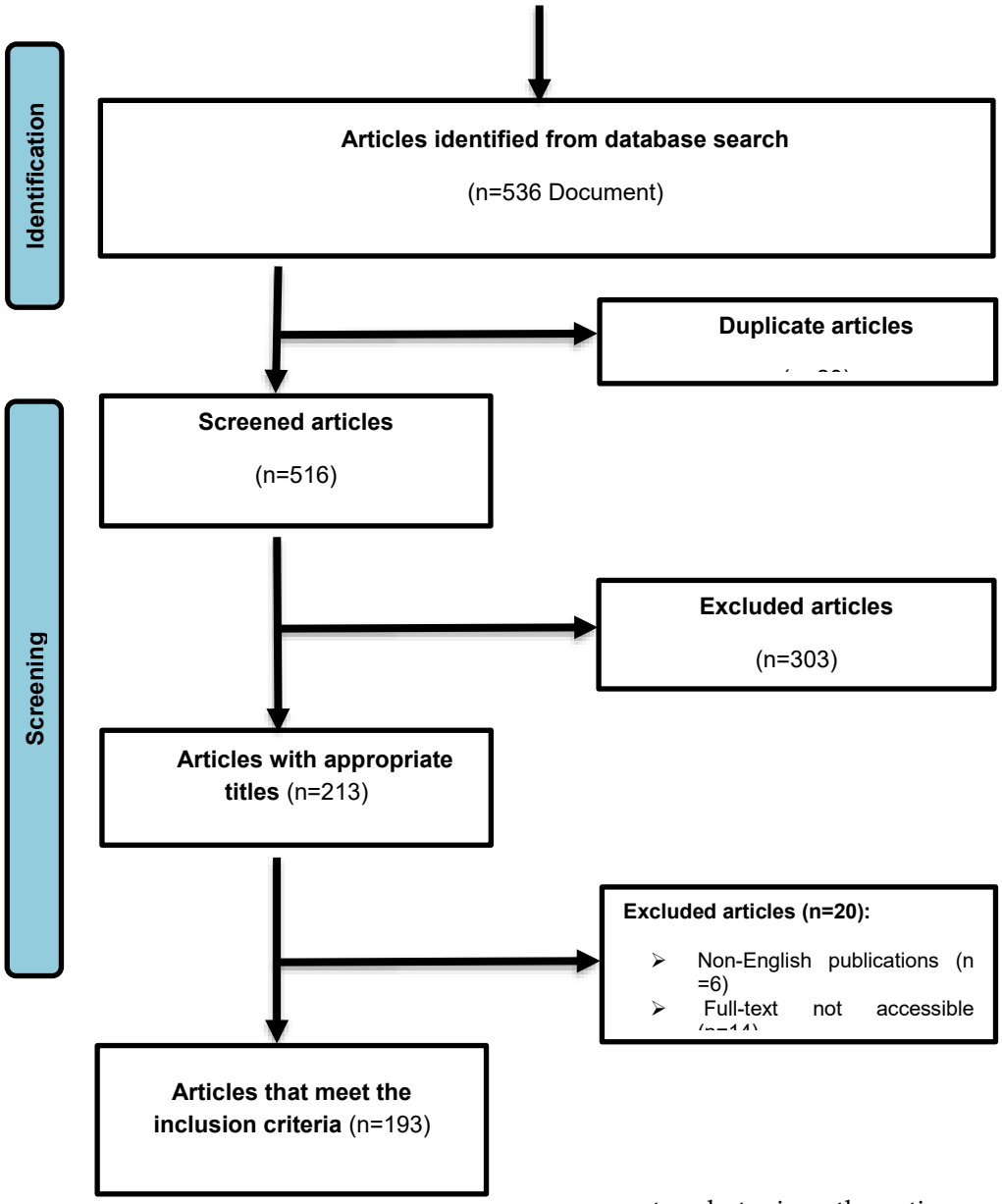
The exclusion criteria were as follows: (1) duplicate records; (2) non-English publications; (3) inaccessible full-text documents; (4) publications other than articles and conference papers, such as editorials, letters, book chapters, notes, and reviews not suitable for bibliometric inclusion; (5) documents unrelated to adolescent contraceptive use, reproductive health behavior, or machine learning-based prediction; and (6) records with incomplete bibliographic metadata that could not be analyzed using bibliometric software.

At the identification stage, 536 records were obtained from both databases. After removing 20 duplicate records, 516 unique documents were screened for eligibility. During the screening stage, documents were filtered based on title relevance, abstract relevance, and document type suitability, resulting in the exclusion of 303 records and leaving 213 potentially relevant documents for further review.

At the eligibility stage, documents were assessed according to predefined inclusion criteria, including: 1) English-language publications, 2) full-text accessibility, 3) original articles and conference papers, 4) final publication stage, and relevance to machine learning–based prediction of contraceptive use or reproductive health behavior. A total of 20 documents were excluded during the eligibility assessment because of non-English publication status (n = 6) and inaccessibility of the full text (n = 14). Consequently, 193 documents met the inclusion criteria and were included in the final analyses.

This selection process strengthened the methodological transparency of the study and ensured that the final dataset represented publications most relevant to the development of machine learning–based prediction of adolescent contraceptive use and reproductive health behavior.





2.3. *Data Analysis*

Data analysis was conducted using several complementary bibliometric software tools to comprehensively address the research questions (RQ1–RQ8). A primary bibliometric analysis was performed using the Bibliometrix package through RStudio and R for Windows to evaluate the scientific performance, conceptual structures, thematic development, and research evolution in the field [19]. Bibliometrix was used to analyze annual publication trends, citation patterns, research life cycles, author and affiliation productivity, country scientific production, core journals based on Bradford's Law, trend topics, thematic mapping, and thematic evolution.

Network visualization and co-occurrence analyses were conducted using VOSviewer software [20]. Specifically, VOSviewer was used to evaluate keyword co-occurrence structures, thematic clusters, conceptual relationships, and network visualizations of research topics. The minimum keyword occurrence threshold was set at three occurrences to improve network stability and reduce low-frequency noise. Network normalization was performed using the association strength method, with clustering generated using the built-in VOSviewer algorithm [21].

Microsoft Excel was used to support the

descriptive quantitative analysis, including data tabulation, document classification, geographical distribution of publications, and visualization of scientific publication trends [22].

The interpretation of bibliometric findings was conducted by linking publication trends, keyword structures, and thematic evolution to the broader implications of reproductive health. In particular, the analysis considered how the emergence of machine learning, random forests, predictive analytics, and data-driven approaches may contribute to adolescent reproductive health programs, early identification of high-risk groups, contraceptive decision support, digital family planning services, and more targeted public health interventions.

Furthermore, thematic interpretation emphasized the relevance of machine learning in understanding the complex and multidimensional determinants of adolescent contraceptive use, including socioeconomic factors, access to health services, reproductive health knowledge, and behavioral risk factors. This interpretive approach allowed the bibliometric findings to be positioned as indicators of scientific productivity and evidence of an emerging direction in AI-supported reproductive health research.

Overall, this bibliometric and science mapping approach enabled a comprehensive evaluation of publication growth, intellectual structures, thematic transitions, scientific collaboration patterns, and emerging research directions related to machine learning–based prediction of adolescent contraceptive use.

3. RESULT

The number of publications obtained at the inclusion stage was 193 over the past four decades (1986–2026). The included documents primarily consisted of original research articles and conference papers published in peer-reviewed journals.

3.1. Annual Scientific Production and Citations per Year.

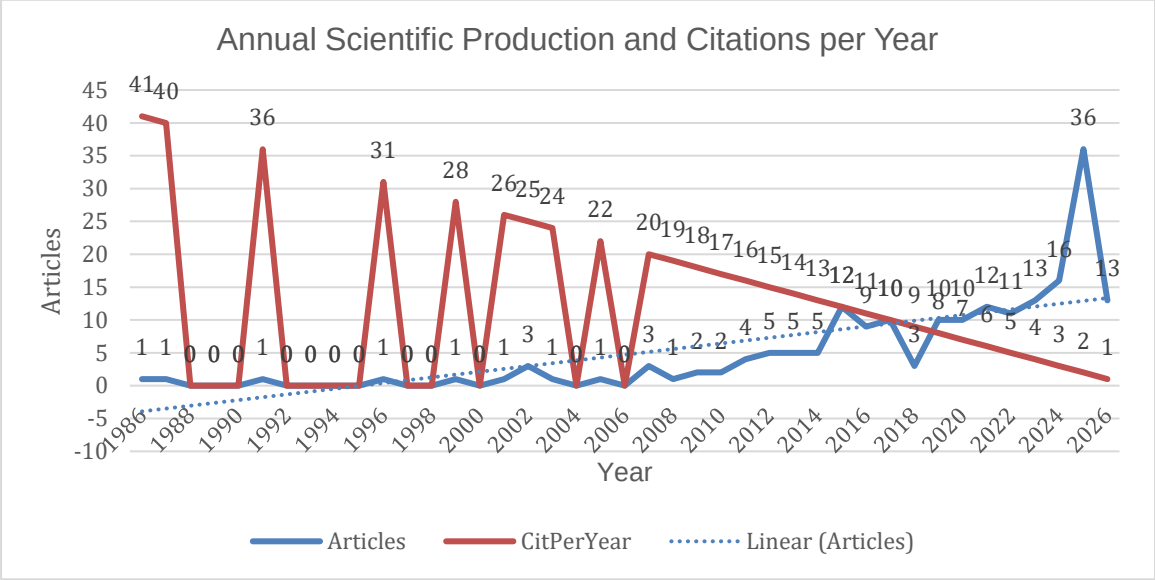


Figure 2: Annual Scientific Production and Citations per Year.

Figure 2 shows the annual scientific production trend and citations per year related to research on machine learning-based prediction of adolescent contraceptive use from 1986 to 2026. The number of publications in the early research phase (1986–2000) remained very low and sporadic, with publications ranging from 0–1 articles per year. An increase began to be observed after 2001, with the number of publications reaching three articles, and then developing gradually during the 2010–2020 period, with an average of 4–12 articles per year. The peak of scientific production occurred in 2025, with 36 publications, and then declined to 13 in 2026. Overall, the linear trend shows a consistent increase in the number of publications over the past four decades. In contrast, the citations-per-year trend shows a different pattern. The highest number of citations was found in the early years of publication: 41 in 1986 and 40 in 1987. Subsequently, the number of citations per year gradually declined, reaching one citation in 2026. These findings indicate that older articles had a longer period of scientific exposure than more recent publications.

3.2. Research Life Cycle of Annual Scientific Publications.

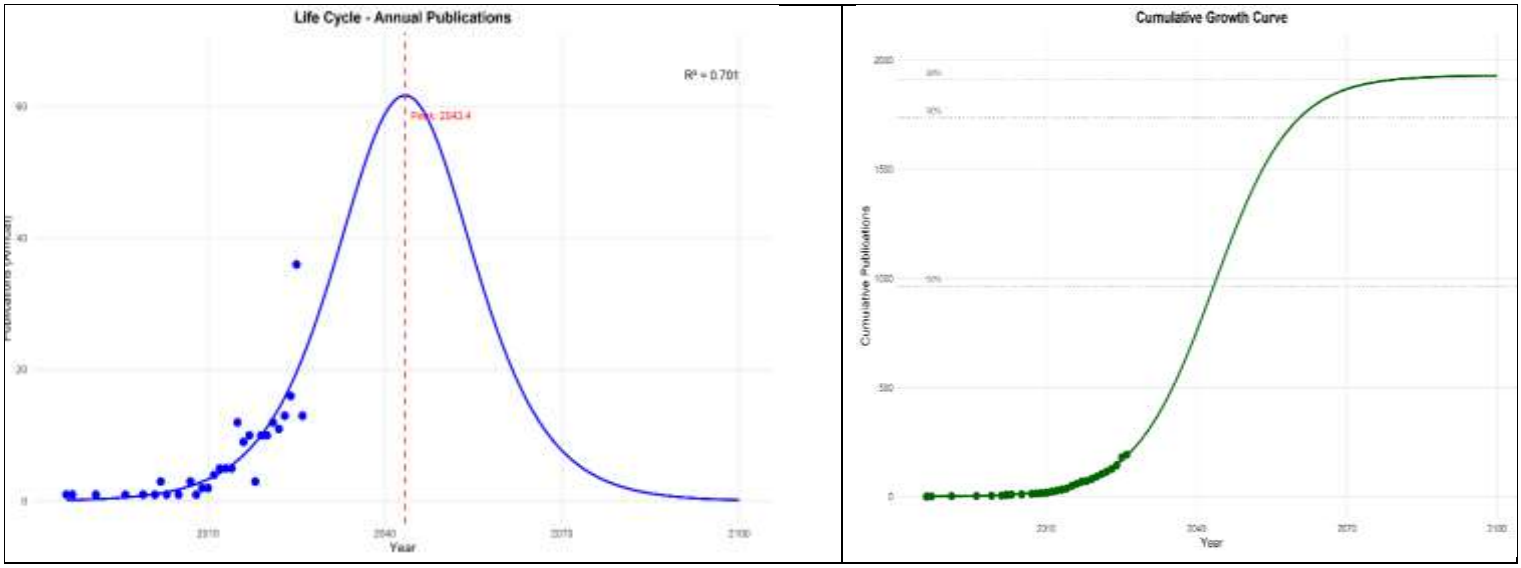
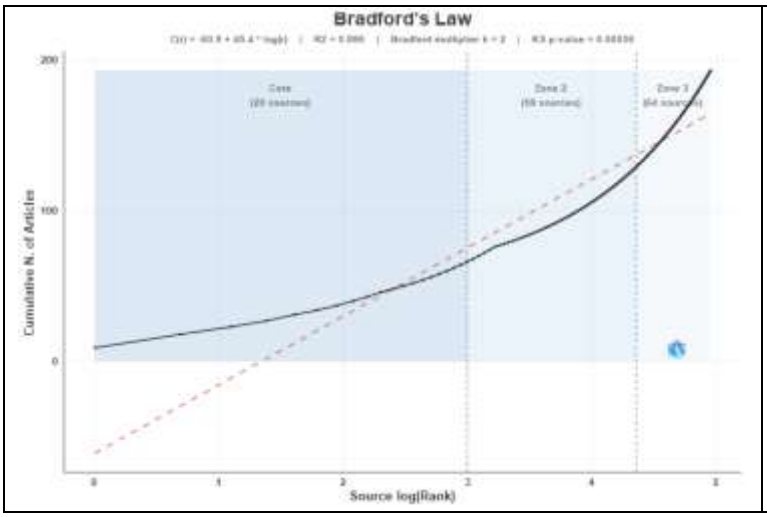


Figure 3. Research Life Cycle of Annual Scientific Publications

Figure 3 shows the Research Life Cycle of Annual Scientific Publications in studies on Machine Learning–Based Prediction of Adolescent Contraceptive Use during the 1986–2026 period. Based on the Life Cycle – Annual Publications curve, the publication growth pattern demonstrated an exponential increase from the early 2000s to the 2020–2026 period. The curve model estimates that the peak growth of publications will occur in 2043.4 with a coefficient of determination of $R^2 = 0.701$, indicating a moderate-to-strong model fit to the annual publication data. In addition, the Cumulative Growth Curve shows a cumulative growth pattern in the form of a sigmoid (S-curve). In the initial period, publication growth was slow, but it significantly accelerated after 2010. The curve shows a sharp increase during the main growth phase, approaching a plateau after 2070. Based on the cumulative results, the number of publications continued to increase progressively during the observation period without any significant decline in the growth rate.

3.3. Most Relevant Sources (Bradford's Law).



ZONE 1				
SOURCES	Rank	Freq	cumFreq	Zone
JOURNAL OF ADOLESCENT HEALTH	1	9	9	Zone 1
PLOS ONE	2	9	18	Zone 1
BMJ OPEN	3	5	23	Zone 1
AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY	4	4	27	Zone 1
CONTRACEPTION	5	4	31	Zone 1
BMC PUBLIC HEALTH	6	3	34	Zone 1
DISCOVER PUBLIC HEALTH	7	3	37	Zone 1
HUMAN REPRODUCTION	8	3	40	Zone 1
JAMA NETWORK OPEN	9	3	43	Zone 1
JOURNAL OF PEDIATRIC AND ADOLESCENT GYNECOLOGY	10	3	46	Zone 1
AMERICAN JOURNAL OF CLINICAL PATHOLOGY	11	2	48	Zone 1
ARTHRITIS CARE AND RESEARCH	12	2	50	Zone 1
BJOG: AN INTERNATIONAL JOURNAL OF OBSTETRICS AND GYNAECOLOGY	13	2	52	Zone 1
BMC INFECTIOUS DISEASES	14	2	54	Zone 1
BMC PREGNANCY AND CHILDBIRTH	15	2	56	Zone 1
BMJ GLOBAL HEALTH	16	2	58	Zone 1
BRITISH JOURNAL OF CLINICAL PHARMACOLOGY	17	2	60	Zone 1
CANCER	18	2	62	Zone 1
CIENCIA E SAUDE COLETIVA	19	2	64	Zone 1
FRONTIERS IN PUBLIC HEALTH	20	2	66	Zone 1

ZONE 2

SOURCES	Rank	Freq	cumFreq	Zone	SOURCES	Rank	Freq	cumFreq	Zone
JOURNAL OF BIOSOCIAL SCIENCE	21	2	68	Zone 2	BRAZILIAN JOURNAL OF MICROBIOLOGY	51	1	102	Zone 2
MATERNAL AND CHILD HEALTH JOURNAL	22	2	70	Zone 2	BREAST CANCER RESEARCH AND TREATMENT	52	1	103	Zone 2
PERSPECTIVES ON SEXUAL AND REPRODUCTIVE HEALTH	23	2	72	Zone 2	CANADIAN JOURNAL OF PUBLIC HEALTH	53	1	104	Zone 2
TROPICAL MEDICINE AND INTERNATIONAL HEALTH	24	2	74	Zone 2	CANCER EPIDEMIOLOGY BIOMARKERS AND PREVENTION	54	1	105	Zone 2
VIROLOGY JOURNAL	25	2	76	Zone 2	CANCER RESEARCH AND TREATMENT	55	1	106	Zone 2
ACADEMIC EMERGENCY MEDICINE	26	1	77	Zone 2	CENTRAL EUROPEAN JOURNAL OF MEDICINE	56	1	107	Zone 2
ACTA OBSTETRICIA ET GYNECOLOGICA SCANDINAVICA	27	1	78	Zone 2	CHILDREN	57	1	108	Zone 2
AESTHETIC SURGERY JOURNAL	28	1	79	Zone 2	CHINESE JOURNAL OF CANCER	58	1	109	Zone 2
AFRICAN JOURNAL OF REPRODUCTIVE HEALTH	29	1	80	Zone 2	CIRCULATION	59	1	110	Zone 2
AIDS	30	1	81	Zone 2	CLINICAL RHEUMATOLOGY	60	1	111	Zone 2
AIDS RESEARCH AND HUMAN RETROVIRUSES	31	1	82	Zone 2	CMAJ	61	1	112	Zone 2
AIDS RESEARCH AND THERAPY	32	1	83	Zone 2	COGITARE ENFERMAGEM	62	1	113	Zone 2
AMERICAN JOURNAL OF EPIDEMIOLOGY	33	1	84	Zone 2	CONTRACEPTION AND REPRODUCTIVE MEDICINE	63	1	114	Zone 2
AMERICAN JOURNAL OF MEDICAL GENETICS, PART A	34	1	85	Zone 2	DEMOGRAPHY	64	1	115	Zone 2
AMERICAN JOURNAL OF MEDICINE	35	1	86	Zone 2	DIGITAL HEALTH	65	1	116	Zone 2
AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY MFM	36	1	87	Zone 2	ECLINICALMEDICINE	66	1	117	Zone 2
AMERICAN JOURNAL OF TROPICAL MEDICINE AND HYGIENE	37	1	88	Zone 2	ENVIRONMENTAL HEALTH PERSPECTIVES	67	1	118	Zone 2
ANNALS OF INTERNAL MEDICINE	38	1	89	Zone 2	EUROPEAN JOURNAL OF EPIDEMIOLOGY	68	1	119	Zone 2
BIOMED RESEARCH INTERNATIONAL	39	1	90	Zone 2	EUROPEAN JOURNAL OF MEDICAL RESEARCH	69	1	120	Zone 2
BLOOD ADVANCES	40	1	91	Zone 2	EUROPEAN JOURNAL OF NEUROLOGY	70	1	121	Zone 2
BMC HEALTH SERVICES RESEARCH	41	1	92	Zone 2	EUROPEAN JOURNAL OF OBSTETRICS AND GYNECOLOGY AND REPRODUCTIVE BIOLOGY	71	1	122	Zone 2
BMC INTERNATIONAL HEALTH AND HUMAN RIGHTS	42	1	93	Zone 2	EUROPEAN JOURNAL OF PREVENTIVE CARDIOLOGY	72	1	123	Zone 2
BMC MEDICAL INFORMATICS AND DECISION MAKING	43	1	94	Zone 2	EUROPEAN JOURNAL OF PUBLIC HEALTH	73	1	124	Zone 2
BMC PEDIATRICS	44	1	95	Zone 2	F1000RESEARCH	74	1	125	Zone 2
BMC PRIMARY CARE	45	1	96	Zone 2	FERTILITY AND STERILITY	75	1	126	Zone 2
BMC WOMEN'S HEALTH	46	1	97	Zone 2	FRONTIERS IN CELLULAR AND INFECTION MICROBIOLOGY	76	1	127	Zone 2
BMC WOMENS HEALTH	47	1	98	Zone 2	FRONTIERS IN GLOBAL WOMENS HEALTH	77	1	128	Zone 2
BMJ (ONLINE)	48	1	99	Zone 2	GE PORTUGUESE JOURNAL OF GASTROENTEROLOGY	78	1	129	Zone 2
BMJ OPEN DIABETES RESEARCH AND CARE	49	1	100	Zone 2					
BMJ OPEN QUALITY	50	1	101	Zone 2					

ZONE 3

SOURCES	Rank	Freq	cumFreq	Zone	SOURCES	Rank	Freq	cumFreq	Zone
GLOBAL HEALTH SCIENCE AND PRACTICE	79	1	130	Zone 3	JOURNAL OF THE AMERICAN ACADEMY OF CHILD AND ADOLESCENT PSYCHIATRY	108	1	159	Zone 3
HEADACHE	80	1	131	Zone 3	JOURNAL OF THE ROYAL SOCIETY INTERFACE	109	1	160	Zone 3
HEALTHCARE (SWITZERLAND)	81	1	132	Zone 3	JOURNAL OF THROMBOSIS AND HAEMOSTASIS	110	1	161	Zone 3
HONG KONG MEDICAL JOURNAL	82	1	133	Zone 3	JOURNAL OF VECTOR BORNE DISEASES	111	1	162	Zone 3
HOSPITAL PEDIATRICS	83	1	134	Zone 3	JOURNAL OF WOMENS HEALTH	112	1	163	Zone 3
INTERNATIONAL JOURNAL FOR EQUITY IN HEALTH	84	1	135	Zone 3	KIDNEY INTERNATIONAL REPORTS	113	1	164	Zone 3
INTERNATIONAL JOURNAL OF EATING DISORDERS	85	1	136	Zone 3	MEDICAL JOURNAL OF AUSTRALIA	114	1	165	Zone 3
INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	86	1	137	Zone 3	MODERN PATHOLOGY	115	1	166	Zone 3
INTERNATIONAL JOURNAL OF EPIDEMIOLOGY	87	1	138	Zone 3	NEW SOUTH WALES PUBLIC HEALTH BULLETIN	116	1	167	Zone 3
INTERNATIONAL JOURNAL OF GENERAL MEDICINE	88	1	139	Zone 3	OBSTETRICS AND GYNECOLOGY	117	1	168	Zone 3
INTERNATIONAL JOURNAL ON ADVANCED SCIENCE, ENGINEERING AND INFORMATION TECHNOLOGY	89	1	140	Zone 3	OPEN PUBLIC HEALTH JOURNAL	118	1	169	Zone 3
INTERNATIONAL NURSING REVIEW	90	1	141	Zone 3	ORPHANET JOURNAL OF RARE DISEASES	119	1	170	Zone 3
JMIR PUBLIC HEALTH AND SURVEILLANCE	91	1	142	Zone 3	PAKISTAN JOURNAL OF LIFE AND SOCIAL SCIENCES	120	1	171	Zone 3
JOURNAL OF ACQUIRED IMMUNE DEFICIENCY SYNDROMES	92	1	143	Zone 3	PAN AFRICAN MEDICAL JOURNAL	121	1	172	Zone 3
JOURNAL OF CLINICAL ENDOCRINOLOGY AND METABOLISM	93	1	144	Zone 3	PEDIATRICS	122	1	173	Zone 3
JOURNAL OF CROHN'S AND COLITIS	94	1	145	Zone 3	PLOS DIGITAL HEALTH	123	1	174	Zone 3
JOURNAL OF EPIDEMIOLOGY AND GLOBAL HEALTH	95	1	146	Zone 3	PLOS GLOBAL PUBLIC HEALTH	124	1	175	Zone 3
JOURNAL OF HEALTH, POPULATION AND NUTRITION	96	1	147	Zone 3	PSYCHONEUROENDOCRINOLOGY	125	1	176	Zone 3
JOURNAL OF HEALTHCARE ENGINEERING	97	1	148	Zone 3	REPRODUCTION AND FERTILITY	126	1	177	Zone 3
JOURNAL OF HEPATOLOGY	98	1	149	Zone 3	REPRODUCTIVE HEALTH	127	1	178	Zone 3
JOURNAL OF INFECTION IN DEVELOPING COUNTRIES	99	1	150	Zone 3	RESEARCH AND PRACTICE IN THROMBOSIS AND HAEMOSTASIS	128	1	179	Zone 3
JOURNAL OF MANAGED CARE AND SPECIALTY PHARMACY	100	1	151	Zone 3	REVISTA ESPANOLA DE NUTRICION HUMANA Y DIETETICA	129	1	180	Zone 3
JOURNAL OF MANAGED CARE PHARMACY : JMCP	101	1	152	Zone 3	REVISTA PAULISTA DE PEDIATRIA	130	1	181	Zone 3
JOURNAL OF MEDICAL INTERNET RESEARCH	102	1	153	Zone 3	SCIENTIFIC REPORTS	131	1	182	Zone 3
JOURNAL OF MEDICAL MICROBIOLOGY	103	1	154	Zone 3	SEXUAL HEALTH	132	1	183	Zone 3
JOURNAL OF MIDWIFERY \& WOMENS HEALTH	104	1	155	Zone 3	SEXUALLY TRANSMITTED DISEASES	133	1	184	Zone 3
JOURNAL OF PRIMARY CARE AND COMMUNITY HEALTH	105	1	156	Zone 3	SOCIAL SCIENCE AND MEDICINE	134	1	185	Zone 3
JOURNAL OF PRIMARY HEALTH CARE	106	1	157	Zone 3	SSM - POPULATION HEALTH	135	1	186	Zone 3
JOURNAL OF RESEARCH IN HEALTH SCIENCES	107	1	158	Zone 3	STROKE	136	1	187	Zone 3
					STUDIES IN FAMILY PLANNING	137	1	188	Zone 3
					SWISS MEDICAL WEEKLY	138	1	189	Zone 3
					TAIWANESE JOURNAL OF OBSTETRICS AND GYNECOLOGY	139	1	190	Zone 3
					THE LANCET	140	1	191	Zone 3
					THROMBOSIS JOURNAL	141	1	192	Zone 3
					TRANSLATIONAL BEHAVIORAL MEDICINE	142	1	193	Zone 3

Figure 4. Most Relevant Sources (Bradford's Law).

Figure 4 shows the distribution of the Most Relevant Sources based on Bradford's Law in the study Machine Learning–Based Prediction of Adolescent Contraceptive Use. Based on the bibliometric analysis of 193 articles, 142 journal sources were distributed into three Bradford zones: Core Zone, Zone 2, and zone 3. The Bradford model yielded the equation $C(r) = -60.9 + 45.4 \times \log(r)$ with a coefficient of determination of $R^2 = 0.886$, a Bradford multiplier (k) of 2, and KS p-value of 0.00536. In the Core Zone, 20 core journals produced a cumulative total of 66 articles. The journals with the highest publication frequencies were the Journal of Adolescent Health and PLOS ONE, with nine articles each, followed by BMJ Open with five articles, American Journal of Obstetrics and Gynecology with four articles, and Contraception, BMC Public Health, Discover Public Health, Human Reproduction, JAMA Network Open, and Journal of Pediatric and Adolescent Gynecology with three articles each.

Zone 2 contained 58 journals with a cumulative total of 129 articles published. Most journals in this zone have a publication frequency of one or two. Several journals in this zone include the Journal of Biosocial Science, Maternal and Child Health Journal, Perspectives on Sexual and Reproductive Health, Tropical Medicine and International Health, BMJ Open Diabetes Research and Care, Digital Health,

and Frontiers in Public Health. Zone 3 comprises 64 journals with a cumulative total of 193 publications. Most journals in this zone published only a single article. Some journals in this zone include Global Health: Science and Practice, Hospital Pediatrics, International Journal of Epidemiology, JMIR Public Health and Surveillance, Open Public Health Journal, PLOS Digital Health, Sexual Health, and Translational Behavioral Medicine journals.

3.4. Most Relevant Authors, Affiliations & Impact

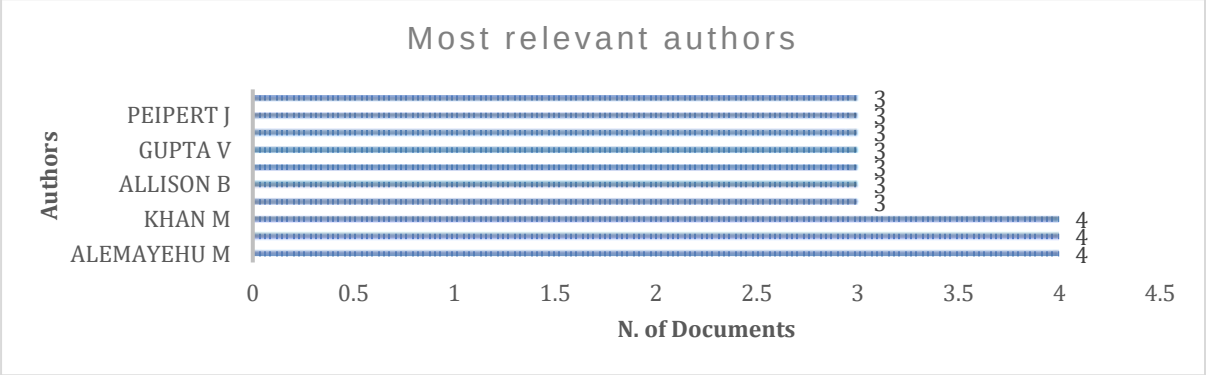


Figure 5. Most Relevant Authors

Figure 5 shows the Most Relevant Authors in the research on machine learning-based prediction of adolescent contraceptive use. Based on the bibliometric analysis results, the authors with the highest number of publications were Alemayehu M, Hossain M, and Khan M, each with four. Furthermore, Ahmed A, Allison B, Arora K, Gupta V, Liu J, Peipert J, and Rahman M each have 3 published documents.

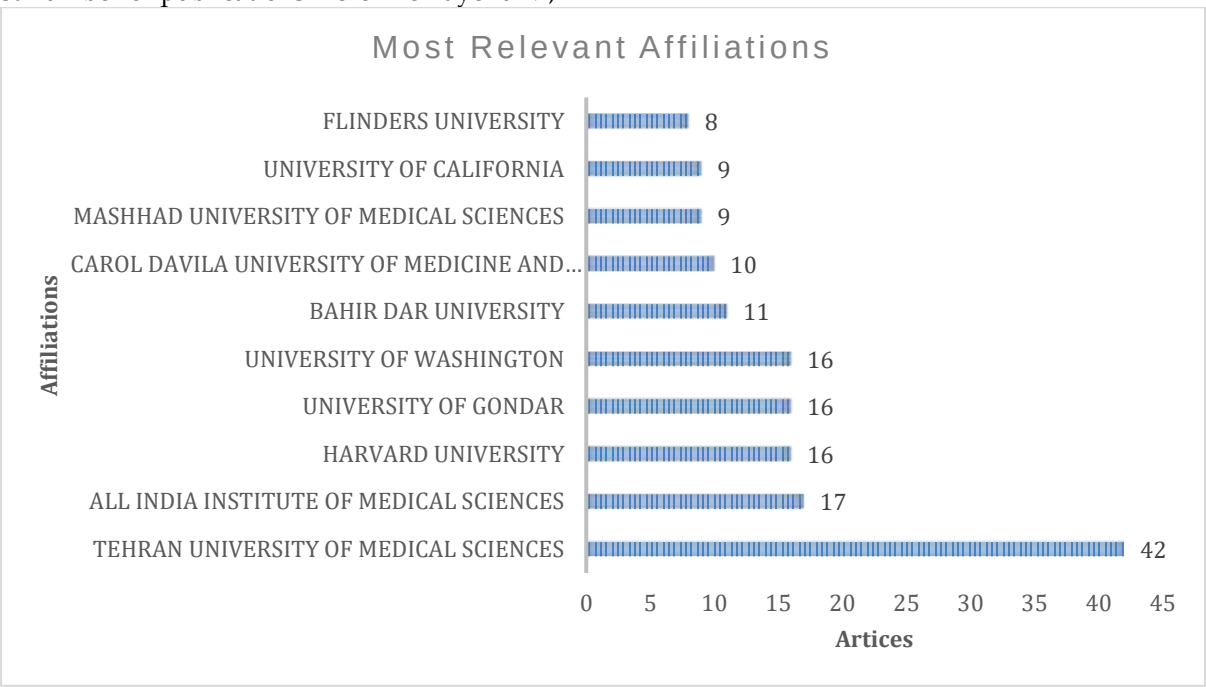


Figure 6. Affiliations

Figure 6 shows the distribution of the Most Relevant Affiliations. The affiliation with the highest number of publications was the Tehran University of Medical Sciences, with 42 articles. The All India Institute of Medical Sciences had 17 articles, followed by Harvard University, the University of Gondar, and the University of Washington with 16 articles. Bahir Dar University published 11 articles, Carol Davila University of Medicine and Pharmacy published 10 articles, and Mashhad University of Medical Sciences and the University of California published nine articles. Flinders University held the second position with eight publications.

Tabel 1. Authors' Local Impact.

Author	h_index	g_index	m_index	Total Citations (TC)	Number of Publications (NP)	Publication Year Start
Khan M	4	4	1,333	1648	4	2024
Gupta V	3	3	1.000	1236	3	2024
Hossain M	3	4	0,600	836	4	2022
Rahman M	3	3	1.000	1236	3	2024
Adekanmbi V	2	2	0,133	515	2	2012
Ahmed A	2	3	0,667	826	3	2024
Bennett K	2	2	0,167	9	2	2015
Bhardwaj P	2	2	0,667	824	2	2024
Cleland J	2	2	0,222	51	2	2018
Das N	2	2	0,050	63	2	1987

Based on Table 1, the h-index is 3, with 1,236 citations and three publications since 2024. Hossain M has the highest g-index of 4 with a total of 836 citations and 4 publications since 2022. Adekanmbi, Ahmed, Bennett, Bhardwaj, Cleland, and Das each had an h-index of 2, with 2–3 publications. The author with the earliest starting publication year is Das N, since 1987.

3.5. Country Scientific Production.

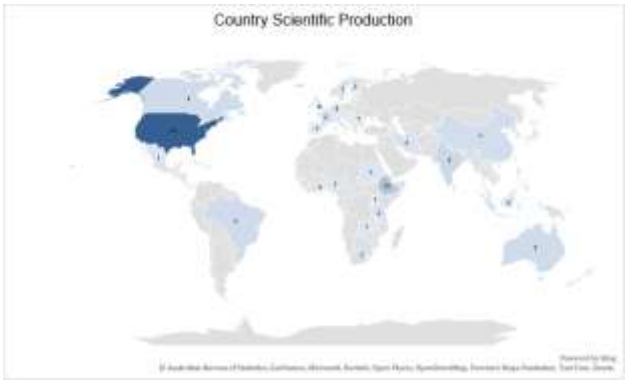


Figure 7. Country Scientific Production

Figure 7 shows the distribution of Country Scientific Production in research on machine learning-based prediction of adolescent contraceptive use. Based on the results of the bibliometric analysis, the United States had the highest number of publications, totaling 54 articles. Ethiopia ranked second, with 15 articles. India and the United Kingdom produced six articles each, while Australia, Brazil, and Canada produced five articles each. China and France produced four articles each. Bangladesh, Denmark, Finland, Italy, South Africa, and Sweden each produced three publications. Germany, Ghana, Indonesia, Iran, Japan, Malaysia, South Korea, and Tanzania each had two publications. Other countries, such as Estonia, Hungary, Ireland, Mexico, Nigeria, Romania, Spain, Sudan, Uganda and Zambia, had one article published. The geographical distribution of publications shows that research related to machine learning–based prediction of adolescent contraceptive use is spread across various regions, including North America, Europe, Asia, Africa, and Australia. However, the highest number of publications remains concentrated in countries with more advanced research capacities and health technology infrastructures.

3.6. Keyword Analysis (Trend Topics).

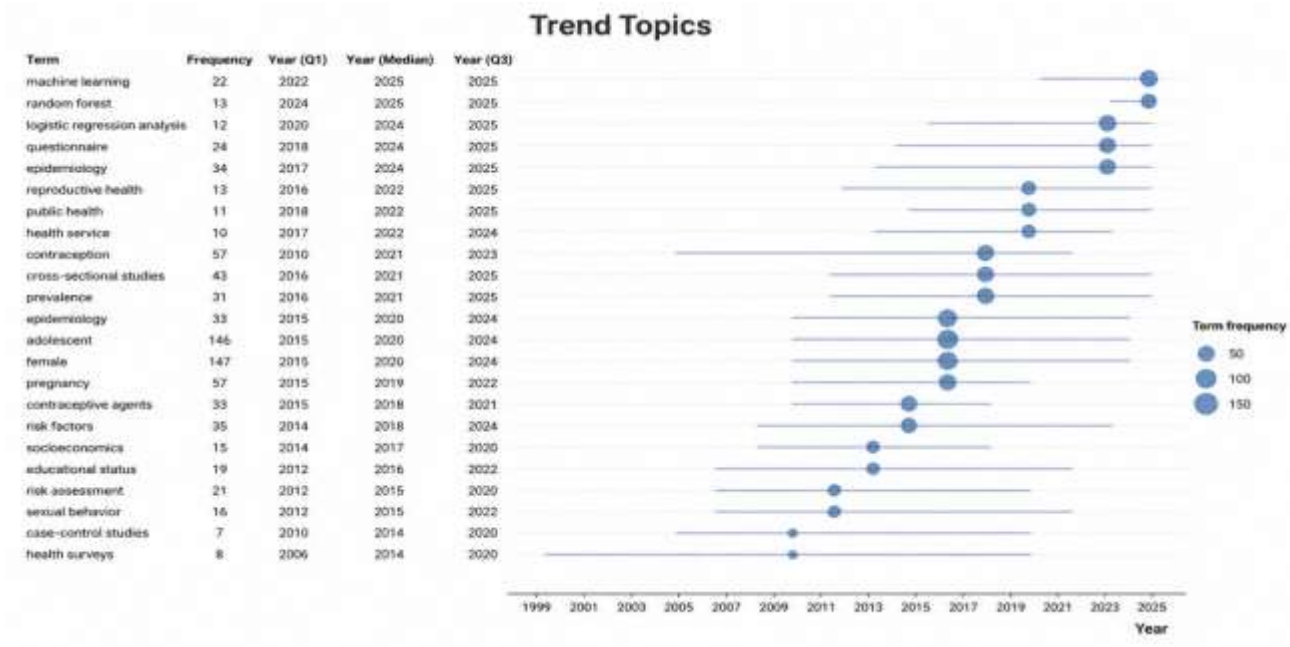


Figure 8. Keyword Analysis Trend Topics

Figure 8 shows the results of the Keyword Analysis Trend Topics in the study of Machine Learning–Based Prediction of Adolescent Contraceptive Use. Based on the results of the bibliometric analysis, the keywords with the highest frequency were female (147 occurrences) and adolescent (146 occurrences), followed by contraception and pregnancy, each with 57 occurrences. Other frequently occurring keywords included cross-sectional studies (43), risk factors (35), epidemiology (34), contraceptive agents (33), prevalence (31), and questionnaires (24). In technology- and machine learning–based topics, the keyword machine learning appeared 22 times, with the first quartile (Q1) in 2022 and a median year of 2025. The keyword random forest appeared 13 times with Q1 in 2024 and a median year of 2025, whereas the keyword logistic regression analysis appeared 12 times with Q1 in 2020 and a median year of 2024. In addition, keywords such as public health, health services, risk assessment, and socioeconomics consistently appeared throughout the observation period.

Temporal distribution shows that early research keywords were dominated by epidemiology and health survey themes, such as health surveys, case-control studies, sexual behavior, and risk assessment, which began appearing between 2006 and 2012. After 2015, research topics shifted toward adolescent reproductive health and determinants of contraceptive use, while after 2020, there was an increase in topics related to machine learning, random forest, and other predictive analytic methods.

3.7. Co-occurrence Network.

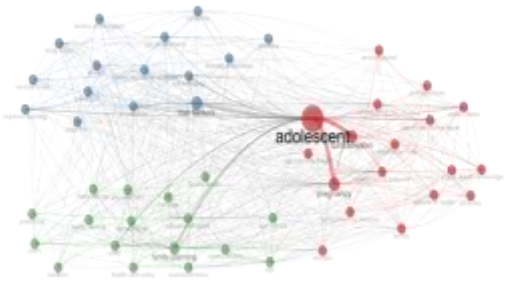


Figure 9. Cooccurrence Network.

Figure 9 shows the results of the Co-occurrence Network analysis in the study Machine Learning–Based Prediction of Adolescent Contraceptive Use. The co-occurrence network illustrates the interconnections between keywords grouped into several main clusters based on their frequency of occurrence and the relationships between research topics. The largest node in the network was adolescent, indicating the highest level of occurrence and interconnection compared to other keywords. In addition, the keyword risk factors also appeared as a central node with strong associations with various research themes. Network visualization revealed the formation of three main clusters distinguished by color. The red cluster was dominated by topics related to adolescents, contraceptive behavior, and

reproductive health risk factors. The green cluster was associated with epidemiology, health surveys, prevalence, and socioeconomic factors of DM. The blue cluster reflects links to analytical approaches, statistical methods, and machine learning–based and predictive analyses. Each cluster demonstrates interconnected relationships through lines (edges) that illustrate the strength of the association between the keywords. Additionally, the co-occurrence network demonstrated a high density of relationships between research topics, especially among keywords related to adolescent reproductive health, epidemiology, and data-driven predictive methods. The inter-node relationships indicate that research in this field is multidisciplinary, involving topics such as public health, reproductive health, epidemiology, and artificial intelligence.

3.8. Thematic Map.

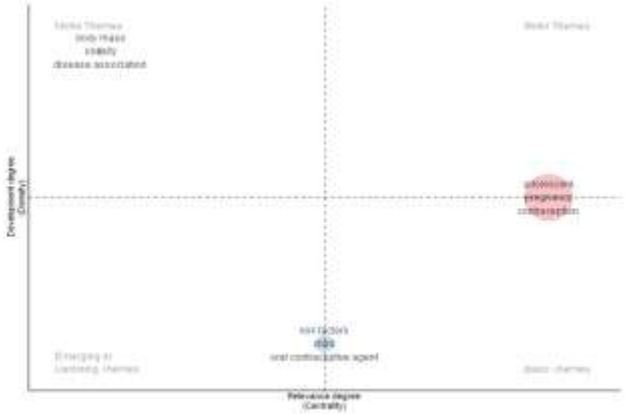


Figure 10. Thematic Map (All Keywords)

Figure 10 shows the results of the Thematic Map (All Keywords) in the study Machine Learning–Based Prediction of Adolescent Contraceptive Use. Thematic mapping was conducted based on two main dimensions: centrality (relevance degree) on the horizontal axis and density (development degree) on the vertical axis. The analysis results show the formation of four main quadrants: motor, niche, basic, and emerging or declining themes. In the Basic Themes quadrant, the main theme consisted of the keywords adolescent, pregnancy, and contraception. This cluster has a high centrality but a relatively moderate density. In addition, the keywords risk factors, child, and oral contraceptive agents were located in the lower area, indicating a lower level of theme development.

In the Niche Themes quadrant, themes such as body mass, obesity, and disease association were identified. These themes have a high density but low centrality. The Motor Themes quadrant did not show any large dominant clusters. Furthermore, in the Emerging or Declining Themes quadrant, no major themes with significant node sizes were found. The node size on the thematic map indicates the frequency of keyword occurrence, while the node position indicates the level of relevance and the development of research themes.

3.9. Thematic Evolution.

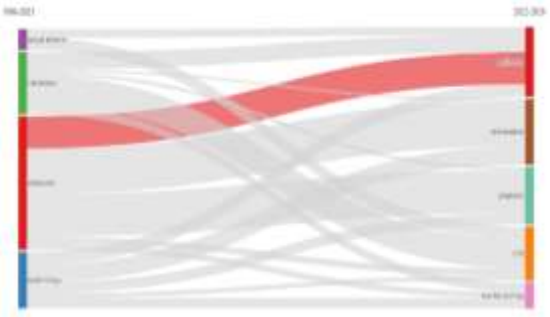


Figure 11. Thematic Evolution

Figure 11 shows the results of the Thematic Evolution in research on machine learning-based prediction of adolescent contraceptive use over two time periods, namely, 1986–2021 and 2022–2026. In the 1986–2021 period, the main research themes were dominated by the keywords adolescent, risk factors, epidemiology, and sexual behavior. The keyword adolescent has the largest node size, indicating the highest frequency of occurrence compared with other themes. In addition, there are network connections linking the initial themes to research themes in subsequent periods. In the 2022–2026 period, research themes developed into adolescent, contraception, pregnancy, child, and machine learning.

The keyword adolescent remained the dominant theme with the strongest connection to previous

research themes. The keywords contraception and pregnancy showed strong relationships with the themes of risk factors and epidemiology in the previous period. In addition, machine learning emerged as a new theme in the most recent period, connected to risk factors and adolescents. The thematic evolution network indicates a shift in the research focus from epidemiological and sexual behavior approaches to predictive analytics and digital technology–based reproductive health approaches. The thickness of the lines in the diagram represents the strength of the connections between the themes from the initial to the subsequent period.

4. DISCUSSION

This study demonstrates that the global research landscape on machine learning-based prediction of adolescent contraceptive use has undergone a significant transformation over the past four decades, particularly since 2020. The sharp increase in scientific output reflects a paradigm shift from conventional reproductive epidemiology approaches toward data-driven reproductive health intelligence, which leverages artificial intelligence (AI) [23], machine learning, and predictive analytics to understand adolescent reproductive health behavior with greater complexity and precision than previously possible. This transformation has occurred alongside the increased availability of digital health data, advances in AI-based computing, and the global need for more adaptive and personalized reproductive health prediction systems [24–26]. Consequently, research on adolescent contraception is no longer solely focused on the descriptive identification of risk factors but is evolving toward the development of predictive systems capable of supporting real-time, evidence-based public health decision-making.

Although publication trends are rising exponentially, the declining citation pattern indicates that this field is still in the active growth phase and has not yet matured. This phenomenon is commonly found in research areas driven by disruptive technology, where a surge in new publications is not yet accompanied by the stabilization of the intellectual structure and long-term citation accumulation [27,28]. The predicted research life cycle, which suggests a potential peak in publication growth around 2043, indicates that this field still has vast room for scientific expansion, particularly in the development of predictive reproductive health systems, personalized contraceptive recommendations, and the integration of AI into digital family planning services [29,30]. These findings show that adolescent reproductive health research is entering a new era that is increasingly integrated with computational and precision public health [25,31,32].

Journal distribution based on Bradford's Law shows that scientific progress remains concentrated within a small number of core journals with multidisciplinary orientations, such as the Journal of Adolescent Health, PLOS ONE, and BMJ Open. The dominance of these journals demonstrates that machine learning-related adolescent contraception research is developing at the intersection of reproductive health, epidemiology, digital health, and health data science. This pattern reflects the growing convergence between public health and modern computational technologies [29]. Conceptually, these results indicate that AI in reproductive health is no longer merely an additional methodological approach but is beginning to form a new scientific subfield within digital reproductive health research [32,33]. Furthermore, the high number of publications in multidisciplinary journals suggests that the issue of contraceptive behavior prediction is increasingly being viewed as a global health challenge that requires integration among the social sciences, epidemiology, and artificial intelligence.

The dominance of several major institutions, such as Tehran University of Medical Sciences, Harvard University, and All India Institute of Medical Sciences, shows that the development of AI-health research is still heavily influenced by digital infrastructure capacity, research resources, and international collaborative networks. The disparity in scientific output between developed and developing countries reveals the existence of global inequality in AI-driven health research, where countries with robust health data systems and high technological investments have an advantage in developing predictive reproductive health models [34,35]. This phenomenon is significant because the majority of adolescent pregnancy burdens and unmet needs for contraception occur in low- and middle-income countries [36,37]. Thus, integrating machine learning into reproductive health has the potential to become a key strategy for reducing global reproductive health service disparities, provided that it is supported by strengthened health data systems and digital capacity in developing nations.

Analysis of trend topics, co-occurrence networks, and thematic evolution revealed the evolution of research themes from traditional epidemiological approaches to AI-based predictive systems. In the

early phase, research was dominated by themes such as sexual behavior, risk factors, and epidemiology, whereas in more recent periods, themes such as machine learning, random forests, and predictive analytics have emerged. This shift indicates that adolescent reproductive health research is transitioning from a "risk identification" paradigm toward "risk prediction and intelligent intervention." In this context, machine learning enables the identification of complex, nonlinear, and multidimensional contraceptive behavior patterns that are difficult to explain using conventional statistical methods [38,39]. In addition, the density of co-occurrence networks shows that research has evolved in a multidisciplinary fashion, with strong integration among epidemiology, public health, reproductive health, and data science. These results reinforce the concept of data-driven healthcare, positioning AI as a central component in the development of precision health systems and big data–driven decision-making [40].

Interestingly, the thematic map indicates that the main themes of research still remain within the Basic Themes category, with no dominant Motor Themes found yet. This suggests that the field of machine learning-based prediction of adolescent contraceptive use is still in the conceptual and methodological exploration phase. In other words, although the use of AI in reproductive health is growing rapidly, its theoretical structure and global research directions have not yet been fully stabilized. This presents significant opportunities for future research development, particularly related to AI, ethical AI in reproductive health, bias and fairness in predictive models, and the integration of AI into community-based family planning services. Ethical issues are especially important because the use of predictive algorithms in adolescent reproductive health has the potential to generate gender bias, socioeconomic bias, and health data privacy risks if they are not developed inclusively and transparently [41–43].

Overall, this study shows that the field of machine learning-based prediction of adolescent contraceptive use is evolving toward a precision reproductive health ecosystem that integrates epidemiology, AI, and digital health to support personalized, predictive, and preventive reproductive health decision making. This study not only maps global bibliometric development but also shows how digital transformation is beginning to change the paradigm of adolescent reproductive health research from a reactive approach to a predictive, AI-based one. These findings make an important contribution to the development of digital reproductive health policy, strengthening public health prediction systems, and shaping the future direction of AI health research in both developed and developing countries.

4.1. Implications

This study demonstrates that the development of predictive models for adolescent contraceptive behavior increasingly relies on the integration of reproductive health data, socioeconomic factors, and artificial intelligence-based computational approaches. These findings have important implications for strengthening digital reproductive health systems, particularly in supporting the identification of high-risk adolescent groups, enhancing the effectiveness of family planning programs, and developing interventions based on population characteristics. Additionally, the dominance of publications from countries with high data and technology capacity highlights the need for investment in health data infrastructure, information system interoperability, and AI literacy in developing countries to prevent widening gaps in reproductive health innovation. This study also underscores the importance of developing transparent, fair, and representative algorithms to reduce the risk of predictive bias in socially and economically vulnerable adolescent populations.

4.2. Limitations

Although the Scopus and Web of Science databases are recognized for their high indexing quality and bibliographic validity in bibliometric research, this study has limitations because publications from other databases, such as PubMed, Dimensions, and Google Scholar, were not included in the analysis. In addition, only English-language articles were included, which may have introduced language bias and reduced the representation of research from non-English-speaking countries, particularly regarding the development of adolescent reproductive health research in developing countries.

5. CONCLUSION

Research developments from 1986 to 2026 indicate that AI-based predictive approaches have begun to play a significant role in adolescent reproductive health. The thematic structure of the research demonstrates a shift in focus from identifying risk factors to developing data-driven behavioral prediction approaches. Although publication growth has increased significantly, the intellectual structure

of this field is still evolving and not yet fully stable, particularly regarding the integration of AI methodologies, public health, and epidemiology into the field. The concentration of publications in certain countries and institutions also indicates that technological capacity and data access remain key factors in the development of global research. Overall, this field holds great potential for developing a scientific foundation for adaptive, precise, and data-driven reproductive health decision-making systems.

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