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*Review*

# Global Trends in Childhood Immunization Research: A Bibliometric Analysis of Publications from 1974 to 2025

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**Abstract:** Childhood immunization is a crucial public health intervention for preventing infectious diseases and reducing mortality. However, global immunization coverage faces challenges such as inequality in vaccine access, the rise of anti-vaccination movements, and the impact of the COVID-19 pandemic. This study aims to analyze global research trends in childhood immunization using a bibliometric approach. Data were collected from the Scopus database, and 629 research articles published between 1974 and 2025 were included in the analysis. The results showed a significant increase in publications over the decades, peaking in 2022. The United States, India, and China were the top contributors, while collaboration patterns revealed the United States and the United Kingdom as the main hubs of the global research network. The research focused on public health, vaccines, child health, and infectious diseases. The study also identified research gaps, including the need for more contextualized studies in developing countries and the integration of technological innovations. Future research should focus on interventions to reduce immunization pain, improve health systems, and address sociocultural barriers to immunization coverage. These findings provide valuable insights for policymakers, health practitioners, and researchers to strengthen childhood immunization programs and promote global child health.

**Keywords:** Childhood Immunization; Bibliometric Analysis; Research Trends; Global Health

## 1. Introduction

Child immunization is one of the most effective public health interventions to prevent infectious diseases and reduce mortality [1]. The World Health Organization (WHO) has long emphasized the importance of immunization programs in achieving optimal global health. Immunization has been crucial in eliminating and controlling several deadly infectious diseases, such as polio, measles, and diphtheria. However, despite the proven benefits of vaccination, implementation challenges remain significant. Inequality in vaccine access between developed and developing countries is one of the main barriers [2]. One of the primary concerns regarding immunization programs is vaccine accessibility. Many low- and middle-income countries (LMICs) struggle with providing adequate vaccine

supplies due to financial and logistical constraints. Insufficient funding, inadequate healthcare infrastructure, and geopolitical factors often hinder the distribution of vaccines to remote areas. This results in lower immunization coverage in vulnerable populations, increasing the risk of outbreaks of preventable diseases. The disparities in vaccine access are further exacerbated by global economic inequalities, where wealthier nations have more resources to secure vaccine supplies than poorer nations [2].

In addition, the rise of the anti-vaccination movement and the spread of misinformation have affected people's perceptions of vaccine safety [3]. Vaccine hesitancy has been recognized as a significant public health issue, with misinformation about vaccines spreading rapidly through social media and other digital platforms. False claims linking vaccines to autism, infertility, or other health issues have contributed to public skepticism and fear. As a result, vaccine refusal or delay has been observed in various parts of the world, leading to outbreaks of preventable diseases such as measles and whooping cough. Addressing vaccine hesitancy requires comprehensive public health strategies, including education campaigns, transparent communication, and engagement with community leaders to rebuild public trust in vaccines [3].

The COVID-19 pandemic has also disrupted routine immunization services, resulting in a decline in global vaccination coverage. For example, recent reports have shown that global DTP (Diphtheria, Tetanus, and Pertussis) vaccination coverage has decreased from 86% in 2019 to 84% by 2023 [4]. This decline indicates the need to evaluate and strengthen immunization programs in various countries to prevent the increasing risk of vaccine-preventable disease outbreaks. Many healthcare facilities redirected their resources to COVID-19 response efforts, causing disruptions in routine immunization schedules. The closure of clinics, restrictions on movement, and public fear of contracting COVID-19 at healthcare centers further contributed to decreased immunization rates [4].

To address these challenges, research plays a crucial role in supporting and improving child immunization programs. Through research, new vaccines that are more effective and safer can be developed, and the factors that influence vaccine acceptance in the community can be identified. In addition, research assists in evaluating the effectiveness of current immunization programs, allowing for the development of more optimal evidence-based health policies [5]. Researchers have explored various strategies to enhance immunization coverage, including mobile vaccination units, community health worker engagement, and digital tracking systems to monitor immunization status. These innovations aim to bridge gaps in immunization coverage and ensure that vaccines reach children in hard-to-reach areas [5].

A bibliometric analysis is one method used to understand the development of child immunization research [6]. This method allows the identification of research trends, collaboration patterns between researchers and institutions, and dominant topics in the scientific literature. In the context of childhood immunization, bibliometrics can reveal areas of research that have been widely explored and those that have received less attention. It also helps identify the field's most influential journals and articles, providing directions for future research agendas [7]. Bibliometric studies have shown that research on childhood immunization has expanded significantly over the past few decades, reflecting the global commitment to improving immunization coverage and effectiveness [7].

Over the past few decades, there has been a significant increase in the number of scientific publications related to childhood immunization, reflecting the scientific community's attention to the importance of vaccination in global child health. However, the distribution of research is uneven, with most studies coming from developed countries, such as the United States, the United Kingdom, and Germany. A bibliometric analysis shows that the dominant research topics in child immunization studies include vaccine effectiveness, safety, and social determinants that affect immunization coverage [7]. In addition, innovations in vaccine delivery strategies, such as noninvasive methods and more flexible immunization schedules, are major research concerns [8]. However, there is still a gap in research participation from developing countries, which should be a primary focus, given the region's high burden of infectious diseases.

Collaboration between researchers and institutions is key to improving the quality and coverage of childhood immunization research. Leading institutions such as Johns Hopkins University and the London School of Hygiene & Tropical Medicine are essential in producing high-quality research. These international collaborations improve access to research resources and enable a more comprehensive understanding of the challenges and solutions in childhood immunization [9]. However, there are still gaps in the involvement of institutions from developing countries that require more attention so that immunization policies and strategies can be tailored to local needs. Strengthening research collaborations between developed and developing nations could facilitate knowledge exchange and

promote locally relevant immunization strategies [9].

Diverse methodologies have been used in childhood immunization research to ensure the validity and reliability of findings [10]. Epidemiological studies are often used to understand the patterns of disease spread and the impact of vaccination on pediatric populations [11]. Clinical trials are key to testing the safety and effectiveness of new vaccines before they are disseminated to the public [12]. In addition, health policy analysis helps assess the implementation of immunization programs and identify areas that require improvement. Community-based approaches are also used to understand community perceptions of vaccination and develop interventions that fit the local context. Although many studies have been conducted, child immunization studies must address gaps [13]. One is the lack of data from low-income countries, which have a high burden of infectious diseases but minimal research contributions. In addition, research on the long-term impact of vaccination and its effectiveness against new disease variants is limited [14].

This article aims to analyze global research trends related to childhood immunization using a bibliometric approach, hopefully providing comprehensive insights into research development in this field [15]. The results of this analysis can serve as a reference for academics to identify under-researched areas. Policymakers and health practitioners can utilize these findings to formulate more effective strategies to improve the coverage and effectiveness of child immunization programs. Thus, this study contributes to the global efforts to improve child health through optimal immunization. Future research should focus on developing vaccines that provide broader protection against emerging pathogens and exploring novel delivery methods to enhance vaccine accessibility and compliance rates.

Furthermore, addressing socio-cultural factors influencing vaccine acceptance is essential. Studies have shown that religious beliefs, cultural perceptions, and mistrust of healthcare systems significantly impact vaccination decisions in various regions. Strategies such as community engagement, culturally sensitive educational campaigns, and policy adjustments can help mitigate vaccine hesitancy and improve immunization uptake. Governmental and non-governmental organizations should work together to implement targeted interventions that address barriers to immunization while ensuring equitable access to vaccines worldwide [15].

In conclusion, while childhood immunization remains a cornerstone of global public health, challenges such as vaccine hesitancy, disparities in access, and research gaps must be addressed. Through continued research, collaboration, and policy improvements, immunization programs can be optimized to protect children worldwide from vaccine-preventable diseases. Using bibliometric analysis provides valuable insights into research trends and highlights areas requiring further investigation. Integrating innovative technologies, strengthening healthcare infrastructure, and promoting public trust in vaccines are essential steps toward achieving comprehensive immunization coverage and reducing the burden of infectious diseases globally.

## 2. Literature Review on Child Immunization

Immunization is widely recognized as one of the most effective strategies for preventing infectious diseases in children. It is crucial in reducing morbidity and mortality associated with vaccine-preventable diseases. Romanin et al. confirmed that vaccination can reduce the incidence of diseases such as measles, diphtheria, pertussis, and pneumonia by 90%. These findings underscore the importance of high immunization coverage in maintaining herd immunity and preventing outbreaks. Additionally, various clinical trials have proven the safety of vaccines, with common mild side effects such as fever and pain at the injection site [16]. However, while vaccines have been instrumental in controlling infectious diseases, ongoing research is essential to improve their effectiveness and minimize side effects. In particular, the emergence of new variants of viruses and bacteria necessitates continuous advancements in vaccine development to ensure optimal protection.

Beyond the biomedical effectiveness of vaccines, social and cultural factors play a pivotal role in determining the success of immunization programs. Vaccine hesitancy, often driven by misinformation, religious beliefs, and lack of trust in healthcare providers, remains a significant barrier to achieving widespread immunization coverage. A study by [17] found that cultural beliefs and community perceptions regarding immunization often influenced vaccine refusal and delays. Low health literacy and distrust of health services compound these issues, leading to vaccine hesitancy in specific populations [17]. This highlights the need for culturally tailored health communication strategies addressing particular community concerns and misinformation. Community-based approaches, including engagement with local leaders and religious figures, have enhanced vaccine awareness and acceptance.

The COVID-19 pandemic significantly impacted global immunization efforts, disrupting routine childhood vac-

cinations in many countries. Ram et al. identified key factors contributing to this decline, including mobility restrictions, shortages of healthcare workers, and an increase in vaccine hesitancy fueled by misinformation related to COVID-19 vaccines [18]. As a result, immunization programs faced setbacks, increasing the risk of outbreaks of vaccine-preventable diseases. Governments and health organizations have implemented strategic recovery plans to address these challenges. These include mobile immunization services, catch-up vaccination campaigns, and integrating immunization with other health services such as maternal and child health programs [19]. These strategies are critical for restoring immunization rates and preventing the resurgence of infectious diseases.

Technological advancements have introduced innovative approaches to vaccine delivery to improve immunization coverage and accessibility. Researchers have developed non-invasive vaccine administration methods, such as nasal and microneedle patches, which simplify vaccine distribution and storage, particularly in low-resource settings. Recent studies have also highlighted the potential of mRNA-based vaccines, which offer advantages such as faster development and adaptability to emerging pathogens [20]. Furthermore, the integration of digital health technologies has enhanced immunization programs. App-based vaccine reminders, electronic health records, and artificial intelligence-driven immunization scheduling have improved parental compliance with vaccination appointments [21]. While these innovations hold great promise, challenges remain, including the need for robust healthcare infrastructure and equitable access to technology, especially in resource-limited settings.

In conclusion, immunization remains a cornerstone of public health, preventing infectious diseases and saving millions of lives globally. However, achieving high immunization coverage requires a multifaceted approach that combines biomedical advancements, effective health communication, and strategic program implementation. Addressing vaccine hesitancy through culturally sensitive interventions, ensuring equitable access to vaccines, and leveraging technological innovations will be key to strengthening immunization programs worldwide. As the world continues to face evolving infectious disease threats, sustained investments in immunization research and public health infrastructure are essential to safeguard global health.

## 3. Research Objectives

This study aimed to determine global research trends in child immunization over the last five decades. The research questions addressed in this study are as follows:

(1) What is the trend in research publications on child immunizations?
(2) What are the citation trends in research on childhood immunizations?
(3) What is the geographical distribution of research on child immunization?
(4) What are the collaboration patterns in research on child immunization?
(5) What is the focus of the research on child immunization?
(6) What is the novelty of the research on childhood immunization?

## 4. Methods

(1) Study Design

The study employed a bibliometric analysis approach, a well-established quantitative method used to examine trends in scientific publications within a specific research domain. This method follows a systematic process [22], which includes four primary stages: identification, screening, eligibility, and inclusion, as outlined in previous studies (**Figure 1**). The primary data source for this analysis was the Scopus database, ensuring a broad and credible representation of global research on childhood immunization. The selection of Scopus as the central database is justified by several factors that enhance the reliability and validity of the analysis. Scopus is one of the largest and most reputable scientific databases, indexing over 25,000 peer-reviewed journals across multiple disciplines, including health and immunization research. Its rigorous selection criteria ensure that only high-quality and methodologically sound studies are included, reducing the risk of incorporating low-quality or non-peer-reviewed publications.

Additionally, Scopus provides extensive bibliometric indicators such as citation counts, h-index, and institutional collaboration metrics, which are crucial for identifying research trends, mapping influential contributors, and assessing the global impact of childhood immunization studies. Compared to other databases, Scopus offers a more comprehensive and internationally representative dataset, minimizing regional bias and ensuring that the findings

are relevant for developed and developing countries. Furthermore, using Scopus allows for better comparability with previous bibliometric studies in the field, maintaining consistency in research methodology and enabling more meaningful cross-study comparisons. Using bibliometric methods with Scopus as the primary source, this study systematically assessed publication patterns, research collaboration networks among scholars and institutions, and the dominant themes in the field. The findings contribute to a comprehensive mapping of the academic landscape of childhood immunization, offering insights into emerging trends, key contributors, and potential research gaps that require further exploration to enhance global immunization efforts.

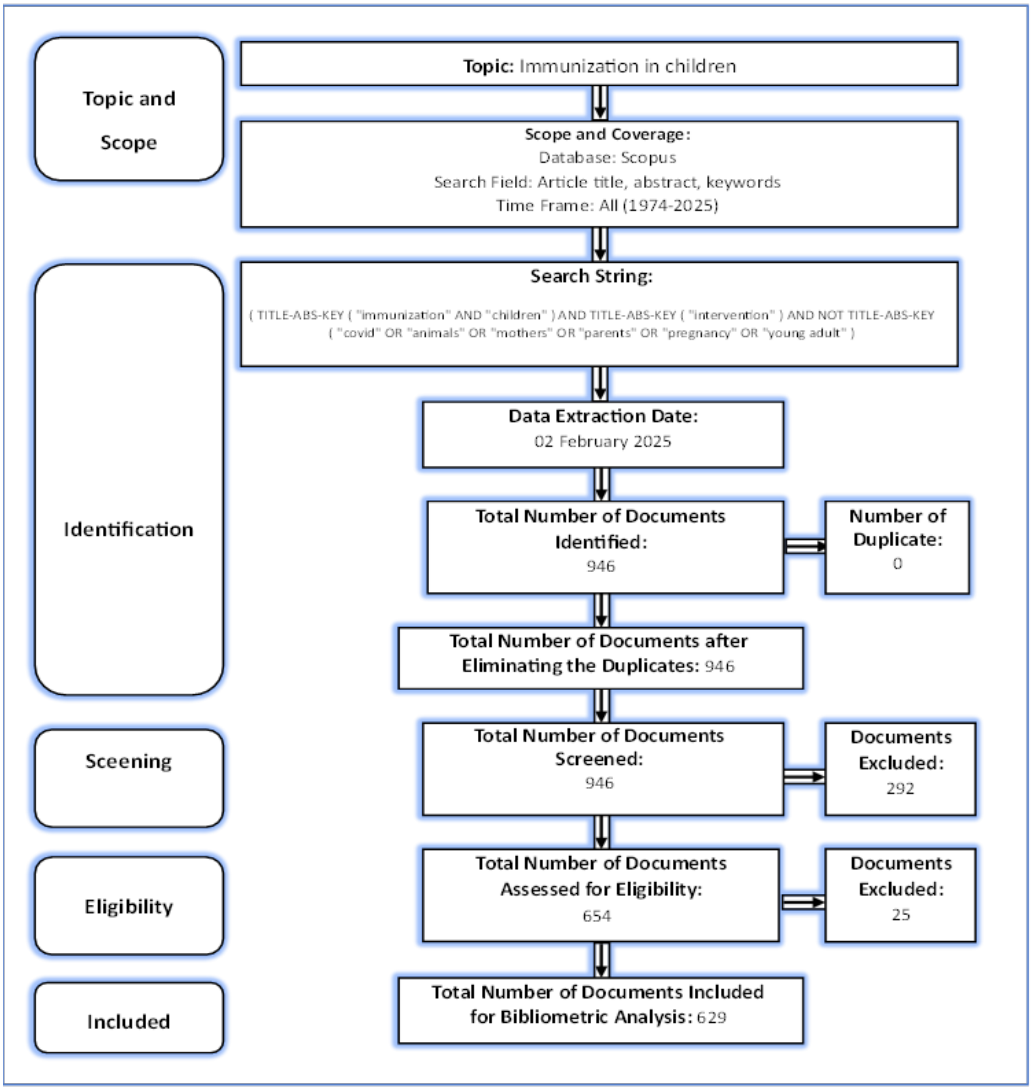


**Figure 1.** Data Collection Process.

(2) Data Collection

In this article, the selection of search keywords is quite long and complex, and it is important to ensure that the research retrieved from the Scopus database is relevant to childhood immunization. The main keywords used, namely "immunization," "children," AND "intervention," are designed to filter studies that specifically discuss immunization in children and interventions related to increasing vaccination coverage or effectiveness. However, several words are deliberately excluded using the NOT operator, such as "covid," "animals," "mothers," "parents," "pregnancy," and "young adult." This exclusion was done to avoid research focusing more on the COVID-19 vaccine, given the many studies on the topic in recent years, so that the analysis remains focused on childhood immuniza-

tion in the context of other vaccine-preventable diseases. In addition, studies related to immunization in animals were removed by excluding the word "animals" to ensure that only research on human immunization is included in the scope of the analysis. Likewise, words such as "mothers," "parents," and "pregnancy" were excluded so that the search results did not include research that focused more on the immunization of pregnant women or parental perspectives on vaccination. The term "young adult" was also removed to narrow the search results and exclude studies focusing on adolescents or young adults. The initial search results (dated February 2, 2025) identified 946 documents that met the search criteria.

The next stage was screening, which involved filtering documents based on document type and source type. In this process, irrelevant documents such as editorials, commentaries, review articles and book reviews were removed, leaving 654 documents that met the initial requirements for further analysis. In the eligibility stage, the eligibility of documents was assessed based on the language of publication, and only articles written in English were included in the analysis. This was done to ensure that the literature used was globally comparable and had a wide academic readership. This process reduced the number of documents that met the criteria to 629. The final stage was inclusion, where the 629 documents that had passed the previous stage were categorized based on research themes and further analyzed. Data collected from these documents included publication titles, author names, year of publication, institutional affiliation, keywords, and number of citations. These data were then processed to identify research patterns in childhood immunization.

(3) Data Analysis

Data analysis was conducted using various software designed for bibliometric processing, namely VosViewer, Harzing's Publish or Perish, and Microsoft Excel [23]. VosViewer was used to visualize the relationship between authors, institutional collaboration, and network analysis of child immunization publications' most frequently used keywords [24]. Harzing's Publish or Perish helps evaluate the impact of publications based on the number of citations and the h-index of a particular author or institution [25]. Microsoft Excel was used for quantitative data processing, including trend analysis of the number of publications per year, the geographical distribution of research, and the analysis of the most dominant research categories [26]. This analysis covered various aspects of the scientific literature on childhood immunization, including publication trends from year to year, collaboration patterns between researchers and institutions, and the most frequently used research methodologies.

## 5. Results and Discussion

The number of publications obtained at the inclusion stage was 629 in the last five decades, from 1974 to 2025. The source of the data was 100% of the research articles.

(1) Publication Trend

**Figure 2** illustrates the trend in the number of publications related to childhood immunization from 1974 to 2025, revealing a significant increase in research output across the decades. In the early period (1974–2000), the number of publications per year remained relatively low, typically not exceeding 10. This suggests that, during these years, childhood immunization may not have been a primary focus of scientific inquiry or policy-driven research at a global scale. However, interest in childhood immunization started gaining momentum in the 1990s, as evidenced by a gradual increase in publications. This growth was likely influenced by the global push for expanded immunization programs led by organizations such as WHO and UNICEF, which worked extensively to increase vaccine access and coverage, particularly in low- and middle-income countries.

A more substantial surge in research publications became evident in the early 2000s, marking a period of heightened global awareness and investment in immunization initiatives. Various factors may have contributed to this acceleration, including establishing the Global Alliance for Vaccines and Immunization (Gavi) in 2000, which provided financial and logistical support to immunization programs worldwide. Additionally, advancements in vaccine technology, such as the introduction of new combination vaccines and vaccine safety improvements, likely influenced research interest.

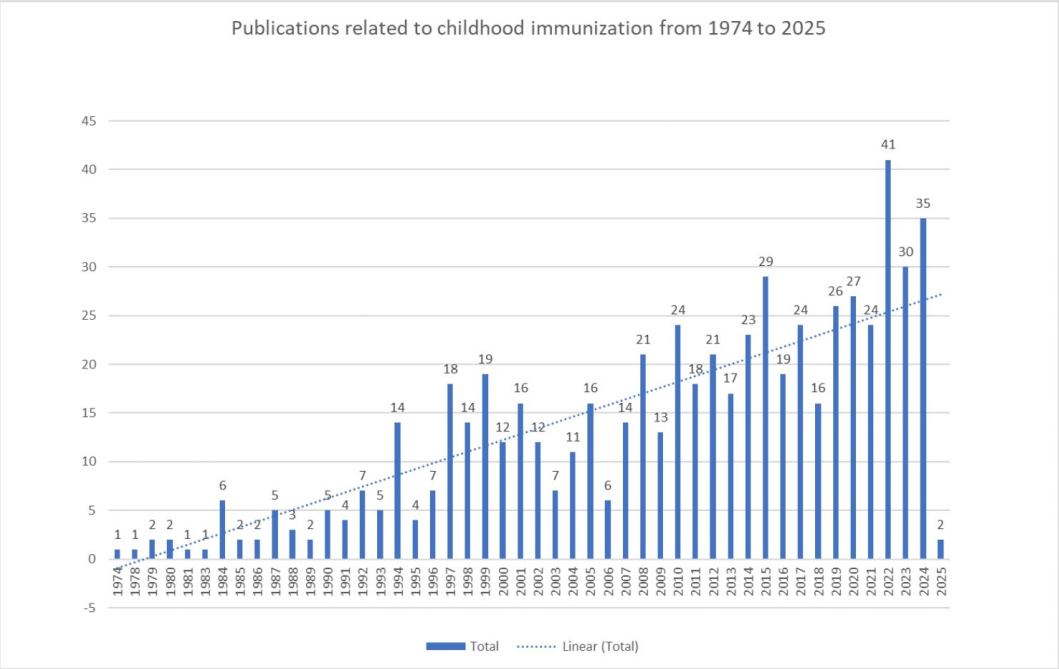


**Figure 2.** Publication Trend.

The upward trend continued steadily over the next two decades, reaching its peak in 2022, with 41 publications. The dramatic rise in research activity surrounding childhood immunization can be attributed to the COVID-19 pandemic, which underscored the critical role of vaccination in disease prevention. The pandemic prompted a surge in studies focused on vaccine development, distribution, public acceptance, and strategies for increasing coverage, not only for COVID-19 vaccines but also for routine childhood immunizations that faced disruptions due to pandemic-related healthcare system strains. Many governments and health organizations prioritized maintaining childhood immunization programs while also managing the challenges posed by COVID-19, leading to increased scholarly output on the subject.

Following the peak in 2022, a decline in publications was observed through 2025. Several factors may explain this trend. One possibility is a natural post-pandemic shift in global research priorities, as attention is diverted to other pressing public health concerns, including non-communicable diseases, mental health, and emerging infectious threats. Another explanation could be a lag in the accumulation and indexing of publication data for the most recent years, meaning that additional studies published in 2024 and 2025 may not yet be fully reflected in available datasets.

Despite the observed decline, the overall trajectory underscores the importance of sustaining a strong research focus on childhood immunization. Continued investigation in this area is particularly vital for countries with persistently low vaccination coverage, where preventable diseases remain a significant public health burden. Policymakers, healthcare practitioners, and researchers must work collaboratively to ensure that immunization programs remain a global priority, fostering innovation and strategies to overcome vaccination hesitancy, improve access, and enhance the effectiveness of immunization campaigns [27].

(2) Citation Trend

The citation trends shown in **Table 1** reflect the dynamics of scientific productivity and its impact over decades. The total publications (TP) showed significant fluctuations, with a peak contribution of 24% in 2010, indicating a period of peak scientific productivity. Cited articles (NCP) and total citations (TC) also saw significant increases in specific years, such as 2008, 2010, and 2005, reflecting the relevance and quality of research in these periods. 2010 was among the most influential years, with the *h, g* indices reaching their highest values of 12 and 21, respectively, indicating that many high-quality articles were published.

**Table 1.** Citation analysis of publications.

| Year | TP | NCP | TC | C/P | C/CP | *h* | *g* |
|---|---|---|---|---|---|---|---|
| 2025 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2024 | 35 | 13 | 28 | 0.8 | 2.15 | 3 | 3 |
| 2023 | 30 | 13 | 68 | 2.27 | 5.23 | 4 | 6 |
| 2022 | 41 | 25 | 330 | 8.05 | 13.2 | 10 | 17 |
| 2021 | 24 | 13 | 111 | 4.63 | 8.54 | 7 | 8 |
| 2020 | 27 | 18 | 254 | 9.41 | 14.11 | 11 | 14 |
| 2019 | 26 | 18 | 961 | 36.96 | 53.39 | 12 | 26 |
| 2018 | 16 | 11 | 424 | 28.25 | 41.09 | 10 | 16 |
| 2017 | 24 | 17 | 596 | 24.83 | 35.06 | 12 | 24 |
| 2016 | 19 | 12 | 441 | 23.21 | 36.75 | 11 | 19 |
| 2015 | 29 | 20 | 630 | 21.72 | 31.5 | 15 | 24 |
| 2014 | 23 | 15 | 690 | 30 | 46 | 13 | 23 |
| 2013 | 17 | 12 | 421 | 24.76 | 35.08 | 12 | 17 |
| 2012 | 12 | 12 | 895 | 42.62 | 74.58 | 12 | 21 |
| 2011 | 18 | 13 | 869 | 48.28 | 66.85 | 13 | 18 |
| 2010 | 24 | 16 | 935 | 38.96 | 58.44 | 16 | 24 |
| 2009 | 13 | 5 | 213 | 16.38 | 42.6 | 8 | 13 |
| 2008 | 21 | 15 | 1180 | 56.19 | 78.67 | 15 | 21 |
| 2007 | 14 | 10 | 562 | 40.14 | 56.2 | 11 | 14 |
| 2006 | 6 | 4 | 174 | 29 | 43.5 | 5 | 6 |
| 2005 | 16 | 5 | 439 | 27.44 | 87.8 | 9 | 6 |
| 2004 | 11 | 7 | 788 | 71.64 | 112.57 | 10 | 11 |
| 2003 | 7 | 6 | 505 | 72.14 | 84.17 | 6 | 7 |
| 2002 | 12 | 5 | 566 | 47.17 | 113.2 | 10 | 12 |
| 2001 | 16 | 10 | 990 | 61.88 | 99 | 12 | 16 |
| 2000 | 12 | 5 | 630 | 52.5 | 126 | 8 | 12 |
| 1999 | 19 | 9 | 653 | 34.37 | 72.56 | 11 | 19 |
| 1998 | 14 | 9 | 982 | 70.14 | 109.11 | 9 | 14 |
| 1997 | 18 | 6 | 627 | 34.83 | 104.5 | 13 | 18 |
| 1996 | 7 | 3 | 209 | 29.86 | 69.67 | 6 | 7 |
| 1995 | 4 | 1 | 57 | 14.25 | 57 | 3 | 4 |
| 1994 | 14 | 4 | 392 | 28 | 98 | 10 | 14 |
| 1993 | 5 | 1 | 161 | 32.2 | 161 | 4 | 5 |
| 1992 | 7 | 1 | 159 | 22.71 | 159 | 3 | 7 |
| 1991 | 4 | 1 | 92 | 23 | 92 | 2 | 4 |
| 1990 | 5 | 0 | 43 | 8.6 | 0 | 2 | 5 |
| 1989 | 2 | 1 | 43 | 21.5 | 43 | 2 | 2 |
| 1987 | 5 | 1 | 165 | 33 | 165 | 3 | 5 |
| 1986 | 2 | 0 | 38 | 19 | 0 | 2 | 2 |
| 1985 | 2 | 0 | 6 | 3 | 0 | 1 | 2 |
| 1984 | 6 | 0 | 32 | 5.33 | 0 | 3 | 5 |
| 1983 | 1 | 0 | 4 | 4 | 0 | 1 | 1 |
| 1981 | 1 | 1 | 111 | 111 | 111 | 1 | 1 |
| 1980 | 2 | 0 | 35 | 17.5 | 0 | 2 | 2 |
| 1979 | 2 | 0 | 23 | 11.5 | 0 | 1 | 2 |
| 1978 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1974 | 1 | 0 | 2 | 0 | 1 | | 1 |

Notes. TP = total of publication, NCP = number of cited publication, TC = total citations, C/P = average citations per publication, C/CP = average citations per cited publication, h = h-index, g = g-index.

The ratio of citations per publication (C/P) and per cited article (C/CP) shows an interesting trend, with 2004 having the highest ratios of 71.64 for C/P and 112.57 for C/CP, indicating that, although the number of publications is small, the impact is enormous in the scientific community. The long-term trend suggests cycles in the contribution of high-quality research, which may be influenced by factors such as changes in the research focus, availability of funding, or the needs of the scientific community. After a peak in 2010, contributions declined until 2025, possibly due to shifting research trends or increased global competition.

A deeper examination of these trends suggests several factors may contribute to the variations in citation impact over time. For instance, periods of high scientific output may correlate with increased research funding, establishing collaborative networks, or groundbreaking discoveries that spark interest among scholars. Conversely, declines in citation impact could be linked to shifts in research priorities, economic downturns affecting funding availability, or the emergence of new methodologies that render previous research less relevant. Moreover, citation

patterns often reflect the dissemination and accessibility of research findings. The adoption of open-access publishing, for example, has played a crucial role in increasing the visibility and impact of scientific publications. Studies have shown that articles published in open-access journals receive more citations than those behind paywalls [28]. This highlights the importance of making research findings widely accessible to maximize their academic influence.

Another key factor influencing citation trends is the interdisciplinary nature of research. Scientific studies that bridge multiple disciplines tend to have a higher citation impact because they attract attention from diverse research communities. In this context, fostering interdisciplinary collaboration can significantly enhance the visibility and influence of scientific output. Encouraging partnerships between researchers from different fields, institutions, and countries can lead to innovative discoveries with broad applications, resulting in higher citation rates. To increase the impact in the future, it is recommended that articles with a high citation impact from previous years be reviewed to learn about their success factors. Analyzing the attributes of highly cited papers, such as their research themes, methodological approaches, and collaborative networks, can provide valuable insights for future studies. New research should focus on relevant and multidisciplinary topics. Identifying emerging trends and aligning research efforts with global scientific priorities can increase the likelihood of producing high-impact publications.

Promoting publications through digital platforms, social media [28], and international conferences can increase visibility and citations [29]. With the proliferation of digital technologies, researchers have more opportunities than ever to disseminate their work to a global audience. Engaging with academic communities on platforms such as ResearchGate, Google Scholar, and LinkedIn can enhance the visibility of publications and foster meaningful collaborations. Additionally, presenting research findings at international conferences provides a valuable opportunity to reach a broader audience, receive feedback, and establish professional connections that can lead to future collaborations. In addition, building international collaborations can strengthen the accessibility and credibility of the research. Collaborative research projects involving multiple institutions from different regions often lead to higher citation rates due to their broader relevance and increased dissemination. Establishing research partnerships with leading institutions and participating in global research initiatives can provide access to valuable resources, funding opportunities, and knowledge exchange, ultimately contributing to higher research impact.

Another promising strategy to enhance citation impact is using keywords and metadata optimization. Ensuring research articles are correctly indexed and contain relevant keywords increases their discoverability in academic databases. Researchers should pay attention to search engine optimization (SEO) principles when selecting titles, abstracts, and keywords to improve the visibility of their publications in digital repositories. Furthermore, mentorship and training programs aimed at improving academic writing and research dissemination skills can help early-career researchers enhance the impact of their work. Providing guidance on how to craft compelling research narratives, structure articles effectively, and engage with broader academic audiences can increase the likelihood of publications being cited. With these strategies, future citation trends are expected to increase significantly [30]. Scholars can enhance the impact of their work by adopting a comprehensive approach that includes reviewing past citation trends, fostering interdisciplinary collaboration, leveraging digital platforms, engaging in international partnerships, and optimizing research visibility. Ultimately, sustained efforts in these areas will advance scientific knowledge and increase research impact over time.

(3) Geographical Distribution of Publications

**Figure 3** shows the global geographical distribution of publications related to childhood immunizations. Countries with the highest number of publications are shown in red, such as the United States (48 publications), demonstrating their dominant role in research related to childhood immunization. Other countries, such as India (37 publications) and China (30 publications), also showed significant contributions, reflecting the large child population and need for immunization in the region. In addition, several countries in Europe, such as the United Kingdom (20 publications) and Germany (14 publications), as well as in Southeast Asian regions such as Indonesia (12 publications), also contributed, albeit with fewer numbers. This distribution suggests that research related to childhood immunization tends to be concentrated in developed and developing countries with large populations. The research capacity, funding availability, and urgency of public health issues in each region may influence this. In contrast, the low number of publications in developing countries may be due to a lack of research resources and academic infrastructure [31].

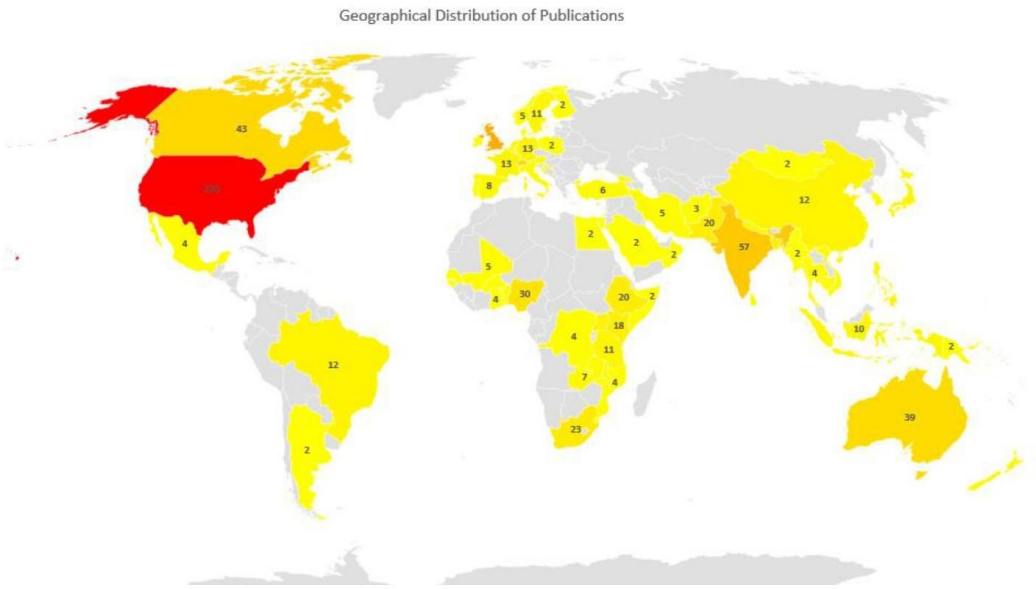


**Figure 3.** Geographical Distribution of Publications.

The figure shows the geographical distribution of scientific publications across countries using a colored world map. The colors on the map indicate the level of publication contribution from each country, where dark red indicates the highest number of publications, as seen in the United States with 170 publications. Orange indicates a fairly high number of publications but lower than red, such as India with 57 publications. Meanwhile, countries in yellow have a medium to low number of publications, and light yellow indicates countries with very few publications. In addition, the numbers in each country represent the number of publications originating from that country. With this visualization, it can be seen that the United States, India, and Australia are countries with a greater contribution to publications than other countries.

A deeper look into the publication trends reveals that research output often correlates with national healthcare policies and funding structures. Countries with well-established research institutions and government-backed health initiatives contribute more extensively to global scientific literature. The United States, for instance, has a robust network of public health organizations, such as the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH), which drive significant research efforts. Similarly, India's high publication count can be attributed to large-scale immunization programs such as Mission Indradhanush, which have led to numerous epidemiological and clinical studies on childhood vaccinations. Furthermore, the presence of international organizations, such as WHO and UNICEF, plays a crucial role in shaping immunization research across different regions. These organizations often collaborate with local governments and research institutions to provide funding, logistical support, and technical expertise. Despite this, gaps remain in certain regions, particularly in parts of Africa and Southeast Asia, where financial constraints and a lack of research infrastructure hinder scholarly output.

This analysis recommends increased global collaboration, particularly to strengthen the research capacity in countries with low publication contributions [32]. For example, more inclusive research funding programs from international agencies could help African and Southeast Asian countries expand their contributions to the global literature [33]. Additionally, it is essential to encourage contextualized and locally driven research to make immunization solutions more relevant and impactful.

Several strategies can be employed to address these disparities in research output. First, developing nations need stronger institutional frameworks to support research activities. Establishing dedicated funding mechanisms for immunization research and fostering public-private partnerships could significantly enhance research productivity. Governments should also focus on building human resource capacities by investing in research training programs and scholarships for young scientists.

Efforts, such as training young researchers, developing global research networks, and open dissemination of re-

search results, will also go a long way to accelerate innovation in childhood immunization globally [34]. Open-access publishing and international research exchanges should be encouraged to facilitate knowledge sharing among scientists from different backgrounds. Additionally, global initiatives that promote technology transfer can assist lower-income countries in establishing research methodologies and analytical frameworks necessary for conducting impactful immunization studies. In conclusion, the global distribution of publications on childhood immunization highlights significant disparities in research contributions. While developed nations dominate the research landscape, developing countries gradually increase their presence due to targeted health programs and international collaborations. A concerted effort is needed to bridge the research gap by enhancing funding, training new researchers, and encouraging cross-border research partnerships. These steps will improve global knowledge of childhood immunizations and lead to the development of more effective and culturally relevant immunization strategies.

(4) Collaboration Patte

**Figure 4** This collaboration map illustrates four clusters of cooperation among 445 countries in research related to childhood immunization, with the United States and the United Kingdom serving as the primary hubs in the global collaboration network. Developed countries such as Canada, Australia, and Germany maintain strong collaborative relationships with these two nations, further reinforcing the global research ecosystem in this field. Meanwhile, developing countries, including India, China, and South Africa, are increasingly active participants in this collaborative network. However, they still depend on developed nations as key partners in advancing their research capacities and implementation strategies.

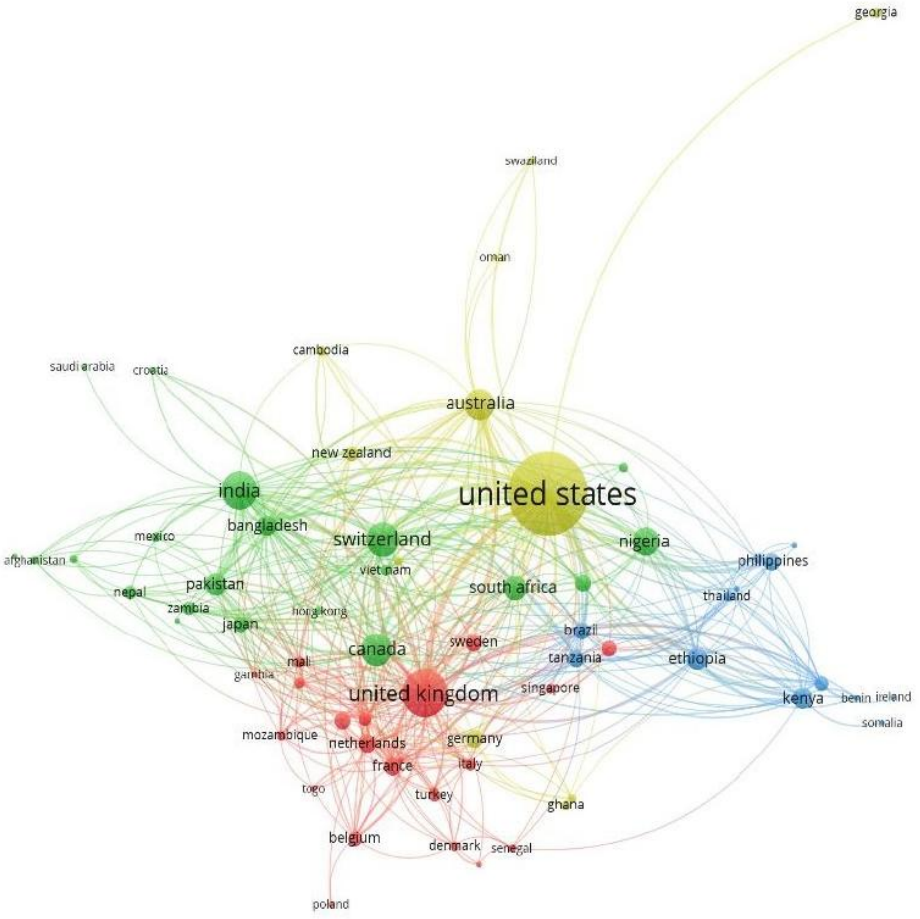


**Figure 4.** Collaboration Pattern.

Indonesia is also present in this collaboration network, but its contribution remains relatively limited compared to other countries. Given its large child population and significant immunization coverage challenges, Indonesia should enhance its role in the global research network. Strengthening cooperation with developed countries with better research experience and capacity—such as the United States, the United Kingdom, and Australia—can significantly improve Indonesia's research output and implementation strategies in childhood immunization [35]. In addition to international collaborations, it is also crucial for Indonesia to establish strong regional research networks within Southeast Asia. Collaborating with neighboring countries allows for exchanging experiences, technologies, and data relevant to local immunization challenges, ultimately leading to more context-specific solutions [36].

One of the key strategies to enhance Indonesia's role in global immunization research is strengthening its domestic research capacity. This can be achieved through increased government investment in research funding, improved training programs for young researchers, and the development of specialized research institutions focusing on childhood immunization [37]. Academic institutions, government agencies, and private sector stakeholders must work together to optimize research efforts and ensure the sustainability of immunization programs. In addition, Indonesia should take advantage of global research funding opportunities offered by organizations such as WHO, UNICEF, and other international donor agencies that support immunization initiatives [38].

Furthermore, cross-sector collaboration between the government, universities, and the private sector is essential to ensure that research findings are effectively translated into policies and programs that can enhance immunization coverage in Indonesia. Public-private partnerships can facilitate technology transfer, capacity-building initiatives, and resource mobilization, all of which contribute to strengthening the country's immunization framework [39]. Through these measures, Indonesia can expand its presence in the global research network and improve the overall quality and accessibility of childhood immunization services within the country. By addressing these key challenges and opportunities, Indonesia has the potential to play a more prominent role in global immunization research. Strengthening international and regional collaborations, investing in research capacity-building, and leveraging global funding mechanisms will allow Indonesia to contribute more effectively to the worldwide effort to improve childhood immunization coverage. These strategic steps will also ensure that Indonesian children receive the best possible immunization services, ultimately leading to better public health outcomes and reduced incidence of vaccine-preventable diseases.

(5) Research Focus

**Figure 5** shows the focus of global research on child immunization, with the term "immunization" at the center of the research network. Larger nodes adjacent to "immunization" represent research themes with strong connections, such as "public health," "vaccines," "child health," and "infectious diseases." The prominence of these themes underscores the primary concerns of global research in this area, namely, protecting children from infectious diseases, improving immunization coverage, and assessing its broader impact on public health. These interconnected research themes highlight the critical role immunization plays in child health and the efforts to mitigate the spread of infectious diseases globally.

Furthermore, other themes such as "nutrition," "maternal health," and "quality of life" emphasize the broader socioeconomic aspects linked to immunization. These connections suggest that immunization is not merely a standalone medical intervention but an integral part of a holistic approach to improving child well-being. Immunization programs contribute to better nutritional outcomes by preventing vaccine-preventable diseases that can compromise a child's growth and development. Additionally, maternal health is closely linked to immunization efforts, as the health and awareness of mothers significantly influence immunization rates and adherence to vaccination schedules. The consideration of "quality of life" in immunization research suggests an increasing recognition of the long-term benefits of immunization beyond disease prevention, encompassing aspects such as educational attainment and economic productivity in later life.

On the other hand, terms such as "delay," "access," and "sociodemographic factors" reveal the global challenges in achieving equitable immunization coverage. Immunization delays are a persistent issue, often caused by logistical barriers, vaccine hesitancy, or sociocultural beliefs that affect timely vaccine administration. Accessibility remains a significant challenge, particularly in remote and underprivileged areas with limited healthcare infrastructure and resources. Sociodemographic factors, including education level, economic status, and geographic location,

are crucial in determining immunization rates. These disparities emphasize the need for targeted strategies to ensure that all children receive timely and complete immunizations regardless of their background.

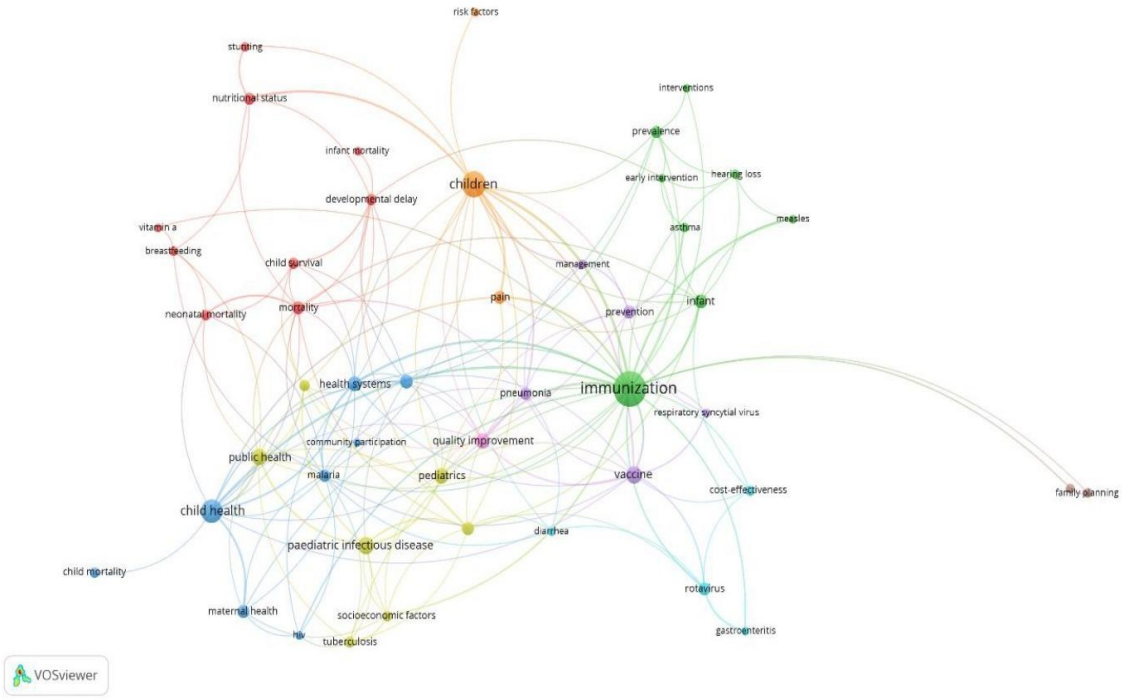


**Figure 5.** Research Focus.

In the Indonesian context, research needs to focus on specific local issues that influence immunization uptake and effectiveness. Access to immunization in remote and rural areas remains a significant challenge due to geographical barriers, inadequate healthcare facilities, and workforce shortages. Immunization coverage inequality is another pressing issue, as disparities exist between urban and rural populations and among different socioeconomic groups. Additionally, cultural beliefs and religious perceptions regarding vaccines continue to influence vaccine acceptance, leading to vaccine hesitancy in specific communities. Understanding these factors through localized research can help develop culturally sensitive interventions that promote higher immunization rates [40].

Another crucial aspect requiring further study in Indonesia is the impact of immunization on children's nutritional status and overall quality of life. Malnutrition remains a significant public health concern in Indonesia, and research should explore how immunization contributes to improving dietary outcomes by reducing the incidence of vaccine-preventable diseases. A more comprehensive understanding of these relationships can support the development of integrated health programs that combine immunization with nutrition and maternal health interventions. Additionally, studies assessing the long-term benefits of vaccination on educational attainment and economic productivity could provide valuable insights for policymakers [41].

Countries with research limitations, including Indonesia, should strengthen evidence-based research to support strategies to increase immunization coverage, particularly in low-coverage areas. Strengthening surveillance systems and utilizing data-driven approaches to identify gaps in immunization coverage can aid in developing targeted interventions. Furthermore, increasing research capacity through funding support, training programs, and academic collaborations can enhance the quality and impact of immunization research. These efforts will provide a more substantial evidence base that informs national immunization policies and strategies [42].

Encouraging collaboration between academia, the government, and non-governmental organizations (NGOs) is essential to effectively address immunization barriers. Academia is crucial in conducting research, analyzing data, and generating evidence-based recommendations. Government agencies are responsible for policy implementation, vaccine procurement, and the overall management of immunization programs. NGOs and community-based or-

ganizations can support grassroots-level interventions, raising awareness and ensuring community engagement in immunization initiatives. Strengthening these partnerships will facilitate a more coordinated approach to overcoming immunization challenges in Indonesia. By adopting these strategic measures, Indonesia can enhance its national immunization programs and contribute significantly to global research trends on child immunization. Bridging the research gap, addressing coverage disparities, and fostering cross-sector collaborations will enable Indonesia to tackle immunization challenges more effectively. As the country continues to advance in its research and policy initiatives, it has the potential to become a key player in shaping global immunization strategies and improving child health outcomes worldwide.

(6) Novelty of Research

**Figure 6** Several novel research ideas can be developed using VOSviewer based on Overlay and Density visualization. First, interventions can be developed to reduce immunization pain in children by utilizing the significant relationship between pain and immunization [43]. This research focuses on technological innovations [44], such as applications or techniques that integrate the Healing Touch approach to reduce pain during immunization, which also expands the benefits of the Healing Touch application developed previously [45, 46]. A key aspect of this research involves exploring the physiological and psychological mechanisms behind pain perception in children during immunization. By understanding these mechanisms, researchers can design more targeted interventions that address the physical sensation of pain and the emotional distress associated with vaccination. Additionally, studies can focus on how different age groups of children respond to various pain-reducing interventions, thus enabling the development of tailored approaches for different pediatric populations.

Second, immunization-based health system improvement could be a key focus, given the strong connections between health systems, community participation, and immunization [47]. This study can help design technology-based interventions that support community health systems, especially in areas with low immunization coverage, such as Indonesia [48, 49]. Digital health solutions, such as mobile applications and telemedicine platforms, can be leveraged to enhance the accessibility and efficiency of immunization services. These innovations can facilitate appointment scheduling, provide educational resources for parents, and offer real-time data tracking to ensure timely vaccinations. Moreover, this research can examine the role of policy frameworks in strengthening immunization programs. Researchers can propose evidence-based recommendations for improving immunization strategies in Indonesia and similar contexts by analyzing successful immunization policies in other countries. Community engagement and participation are also critical aspects that should be explored to identify culturally appropriate methods for increasing immunization uptake.

Furthermore, integrating nursing education and technology for immunization is an interesting research opportunity, given the link between nursing, child health, and quality improvement. Developing a technology-based curriculum for pediatric nurses to manage pain and improve immunization experiences could be a valuable innovation [50]. This initiative can include virtual simulations, interactive modules, and mobile learning applications to enhance nurses' skills in pediatric pain management and immunization procedures. The role of continuing education and professional development programs for nurses can also be explored. By assessing the impact of such programs on immunization service delivery, researchers can provide insights into how ongoing training can improve healthcare outcomes. Additionally, studies can investigate the effectiveness of integrating pain management techniques, such as Healing Touch, into nursing curricula to ensure that future healthcare professionals are well-equipped with non-pharmacological pain management strategies.

In addition, sociocultural factors in immunization coverage can be analyzed by exploring issues related to neonatal mortality, maternal health, and public health [51]. This research evaluates the cultural and social barriers affecting immunization coverage in Indonesia and proposes community-based approaches to overcome them [52]. Sociocultural perceptions about immunization, including myths and misconceptions, play a significant role in determining vaccine acceptance rates. By conducting qualitative and quantitative studies, researchers can identify the main concerns of parents and caregivers regarding immunization and develop targeted educational campaigns to address misinformation. Religious and traditional beliefs can also influence immunization practices. Understanding these factors can help design culturally sensitive interventions encouraging higher vaccine acceptance.

Additionally, the role of community health workers in disseminating accurate immunization information can be studied to determine their effectiveness in bridging the gap between healthcare providers and communities.

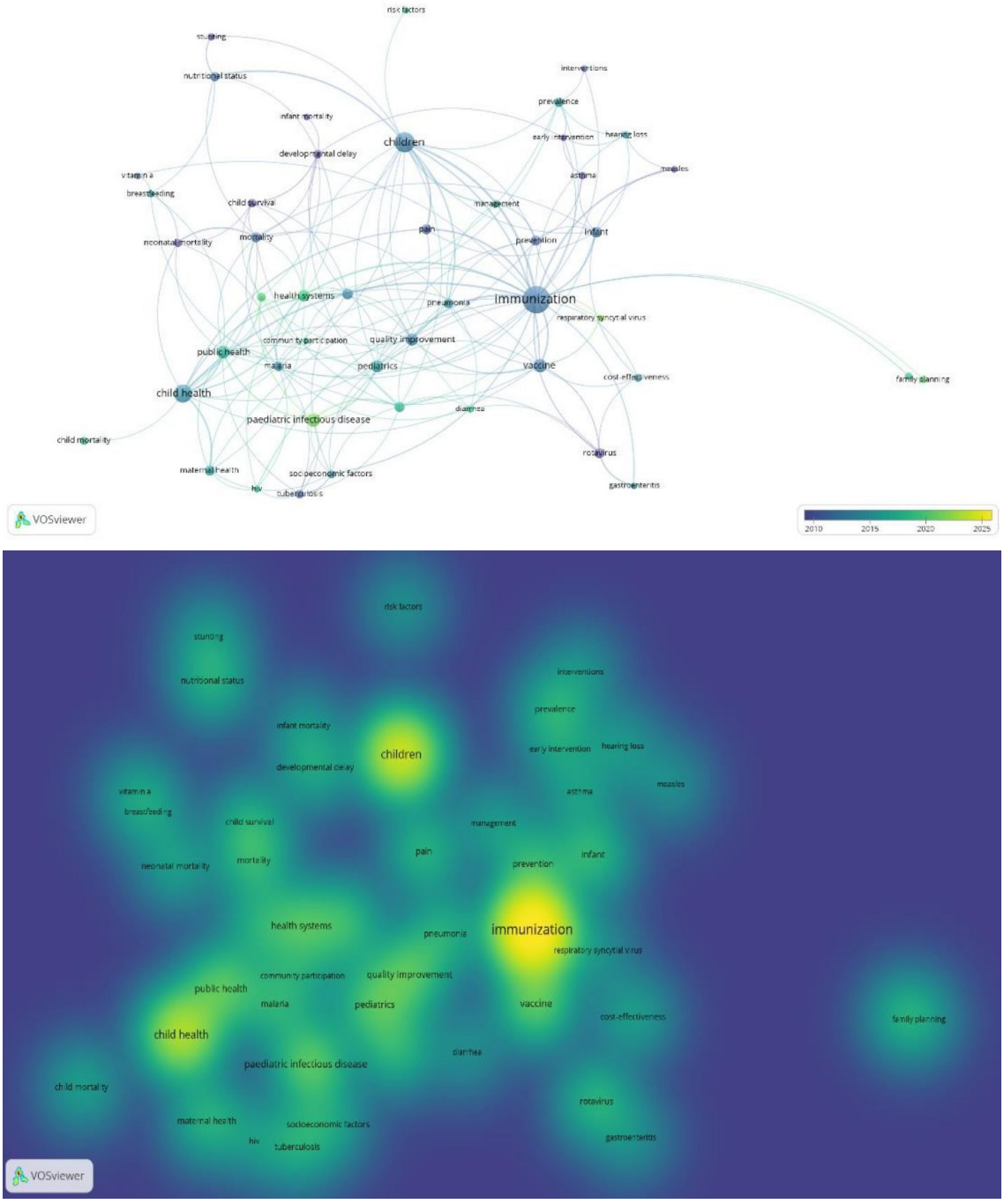


**Figure 6.** Novelty of Research.

Finally, improving the quality of immunization through nursing theory modeling is an important aspect that can be developed, given the potential for prevention, vaccination, and pediatric infectious diseases [53]. This study can help to design intervention theories that support improvements in the quality of child immunization services, resulting in a nursing model that is more effective in improving immunization coverage and quality [54]. Integrating theoretical frameworks in nursing research can provide a structured approach to understanding and addressing immunization challenges. By developing nursing models that incorporate evidence-based interventions, researchers

can contribute to the establishment of standardized best practices for immunization services. Furthermore, this research can explore the impact of nurse-led immunization programs on overall vaccine coverage and healthcare system efficiency. In conclusion, leveraging technology, nursing education, and sociocultural insights can significantly enhance immunization practices. By addressing pain management, strengthening health systems, integrating innovative educational strategies, and understanding sociocultural influences, researchers can develop comprehensive approaches to improve immunization rates. Future studies should focus on interdisciplinary collaborations to create sustainable and effective solutions for immunization challenges globally.

## 6. Implications

These findings significantly improve immunization coverage in Indonesia, particularly in remote and underserved areas with low health literacy. By providing evidence-based strategies, this study supports formulating and enhancing national health policies to strengthen immunization programs. Integrating the Healing Touch application into child immunization services presents a promising approach to increasing parental compliance, reducing vaccine hesitancy, and fostering greater trust in immunization programs within local communities. Moreover, this study highlights the importance of understanding socio-cultural factors that influence immunization coverage, encouraging a more localized and context-specific approach to healthcare interventions. Strengthening local research capacity is essential in identifying barriers and facilitators to immunization, which can inform tailored strategies to enhance vaccine acceptance and accessibility in diverse populations. By empowering local researchers and healthcare practitioners with the necessary knowledge and resources, sustainable solutions can be developed to address gaps in immunization services.

On a broader scale, the implications of this study extend beyond Indonesia, offering valuable insights that contribute to global immunization efforts. The findings create opportunities for international collaboration in developing and implementing more effective immunization strategies, particularly those incorporating technological innovations. Non-invasive pain management methods and digital approaches, such as mobile health applications and telehealth services, can improve the immunization experience for children and caregivers worldwide. Additionally, the study underscores the urgency of addressing disparities in vaccine access by advocating for more inclusive and equitable immunization programs. This research promotes the importance of community-based initiatives and digital health solutions in global immunization monitoring by engaging global health organizations such as WHO and UNICEF. Encouraging these organizations to support localized research efforts and invest in technology-driven immunization programs can significantly reduce vaccine-preventable diseases and ensure that immunization services reach even the most marginalized populations. Ultimately, these findings reinforce the critical role of integrating innovative, evidence-based strategies into public health frameworks to enhance immunization coverage at both national and international levels. By leveraging digital technology, strengthening local research capacities, and fostering global partnerships, this study provides a pathway toward a more efficient, accessible, and equitable immunization system worldwide.

## 7. Limitations

This study has several limitations, including the limited qualitative analysis because most studies analyzed were quantitative. In contrast, socio-cultural factors that influence immunization are often more effectively explained through a qualitative approach. In addition, this study only used the Scopus database as a data source, so publications that are not indexed in Scopus, including local studies and government reports, were not included in the analysis, which has the potential to cause limitations in understanding the context of immunization at the local level. Therefore, further research is recommended to adopt a qualitative approach to explore more deeply the sociocultural factors that influence immunization and expand the scope of data sources by including local studies and government reports so that the analysis is more comprehensive and relevant in the context of developing countries.

## 8. Conclusions

This study shows that the global trend in research on childhood immunization has increased significantly in recent decades. This increase peaked in 2022, marked by an increasing number of scientific publications related to

childhood immunization. Some countries with the most significant contributions to scientific journals in this field include the United States, India, and China. These countries consistently produce diverse and high-quality research on childhood immunization, reflecting their commitment to understanding and increasing vaccination coverage in this age group. On the other hand, developing countries, including Indonesia, are still relatively limited in their participation in research on childhood immunization.

This limitation can be caused by various factors, such as a lack of research resources, low funding for studies in the field of child health, and challenges in accessing comprehensive data on immunization coverage in various regions. Through bibliometric analysis, it can be identified that the main focus of childhood immunization research includes the effectiveness of vaccines in protecting against vaccine-preventable diseases, challenges in implementing immunization programs, and strategies that can be applied to increase vaccination coverage globally. Some of the obstacles that are still a concern in this field include community resistance to immunization due to misinformation or socio-cultural factors, gaps in access to vaccines, especially in developing countries, and the lack of innovation in child-friendly vaccine delivery methods, both in terms of procedures and experiences felt by children during the immunization process.

To overcome these challenges, more intensive efforts are needed to strengthen international collaboration between developed and developing countries to share knowledge, technology, and best practices in immunization programs. In addition, developing innovative technology in vaccine distribution is crucial to ensure that vaccines can reach a broader population, especially in areas with limited health infrastructure. Furthermore, more contextual research is needed in developing countries to understand the specific obstacles faced in implementing childhood immunization so that the resulting solutions can be more appropriate to local social, economic, and cultural conditions.

## Author Contributions

Conceptualization, V.Y.L. and J.N.; methodology, V.Y.L. and I.K.; software, V.Y.L.; validation, V.Y.L., B.V.B. and A.S.; formal analysis, V.Y.L. and S.S.; investigation, V.Y.L.; resources, S.S.; data curation, J.N.; writing—original draft preparation, V.Y.L.; writing—review and editing, J.N.; visualization, V.Y.L.; supervision, V.Y.L.; project administration, V.Y.L.; funding acquisition, V.Y.L. All authors have read and agreed to the published version of the manuscript.

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## Data Availability Statement

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## Conflicts of Interest

The authors declare no conflict of interest.

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