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International Bibliometric Analysis of Literature on Intrauterine Insemination

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ABSTRACT

Intrauterine insemination (IUI) is an artificial insemination method that employs specialized devices to introduce spermatozoa into the uterus. IUI is utilized to address challenges associated with poor reproductive outcomes and to optimize the productivity of livestock. Consequently, its application and utilization has gained global attention and is being continuously developed. Therefore, this study aimed to analyze the global literature on intrauterine insemination research over the preceding decade. Documents related to intrauterine insemination research were presented in the results of a bibliometric study indexed in the Scopus database for the period 2012–2022. On a global scale, the total number of identified documents amounted to 2.721, with an average annual production of 272 documents. Ten countries worldwide were identified as leading contributors to research publications on intrauterine insemination, including the United States with the most document production (n=643), followed by Turkey (n=175), India (n=173), China (n=161), United Kingdom (n=159), Iran (n=153), Netherlands (n=152), Canada (n=140), France (n=131), and Italy (n=129). Publications related to intrauterine insemination showed an upward trajectory from 2012 until 2021, followed by a decline in 2022. The findings from this analysis provide valuable guidance for future research in the field of intrauterine insemination.

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INTRODUCTION

The general process of artificial insemination has been used to treat a variety of physiological and psychological infertility disorders in both male and female, including severe hypospadias, retrograde ejaculation, impotence, and vaginismus. For a long time, IUI has been used to identify poor postcoital conditions and immune system-induced infertility. Nowadays, the utilization of IUI has become more developed and is able to treat infertility due to various conditions. For instance, moderate male infertility, unexplained infertility, optimization of ovulation induction in patients with ovulation disorders. The IUI method has a relatively straightforward protocol that allows it to be performed by nurses at certain health centers, under the supervision of a doctor. Factors that may influence the outcome of IUI include the use of ovulation induction agents, semen analysis parameters, sperm preparation techniques, and the timing and number of inseminations (Abdelkader and Yeh 2009).

Intrauterine Insemination (IUI) involves placement of prepared sperms from the husband (AIH – artificial insemination homologous) or from a donor (AID – artificial insemination donor) into the female genital tract in cases of male factor infertility, cervical and vaginal factors of female infertility, and unexplained infertility. It is usually performed with ovulation induction therapy or controlled ovarian hyperstimulation (COH). COH combined with IUI is usually recommended for couples experiencing infertility due to causes other than the fallopian tubes. IUI became popular because it is a straightforward, non-invasive, and cost-effective procedure. In situations of cervical infertility, anovulation, endometriosis with healthy fallopian tubes, and unexplained infertility, this approach is advised (Sinha et al., 2017). This study aimed to provide a comprehensive analysis on the literature on intrauterine insemination over the last several decades by mapping international collaboration, evaluating the performance of prominent institutions, investigating the performance of prominent institutions, investigating the productivity of prestigious journals, dissecting the characteristics of highly cited articles, and highlighting emerging research topics. The current study's findings may provide a visual overview of research developments in this sector, as well as aid researchers and practitioners in assessing the research's impact.

MATERIALS AND METHOD

The Scopus database was utilized in this bibliometric analysis to acquire all documents on intrauterine insemination published between 2012 to 2022, with the exception of erratum. In the title and abstract fields, the key phrases "intrauterine" AND "insemination" were utilized, and the existing filters were applied to collect publications pertaining to intrauterine insemination. Document type, year, nation, journal title, reference, institution, and important phrases are extracted. The extracted data is subsequently evaluated using the VOS Viewer software based on the specified extraction component (Sofyantoro et al., 2022).

RESULTS AND DISCUSSION

The first paper related to intrauterine insemination was published in 1946. Since then, intrauterine insemination has evolved thanks to developments like sperm preparation, time monitoring for pre-ovulatory periods (Ghanem et al., 2011), and hCG-induced ovulation (hCG) (Berezin et al., 1988). Through the year the number of documents that are published is constantly growing. During the past ten years from 2012 – 2022 there are 2721 documents in total, with 272 average per year. The highest number of documents published is at year 2021 with 307 documents, indicating a high research productivity in the field of intrauterine insemination in recent years (Figure 1).

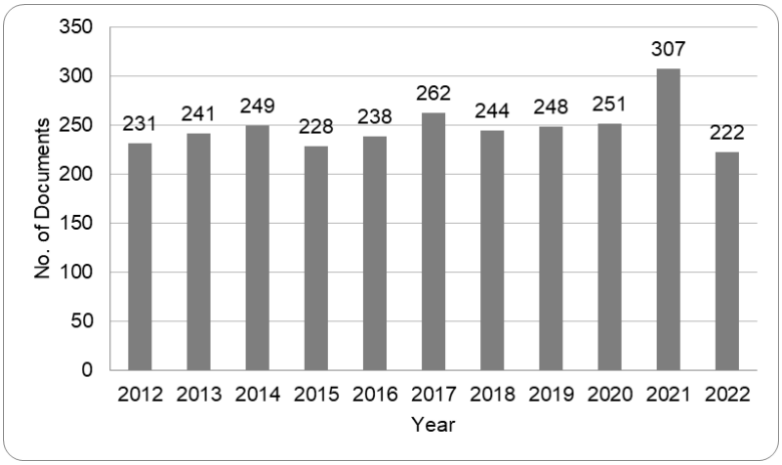


Figure 1. Publication profile of intrauterine insemination-related research from 2012-2022. Documents with a total of 2721 were obtained from the Scopus database. Output in studies with intrauterine insemination has fluctuated annually, with the largest volume of publications occurring in 2021.

Our results show that the United States is the most productive country in terms of intrauterine insemination research (Table 1). It could be explained by the fact that the United States of America's National Institutes of Health (NIH) awarded the highest funding among other countries. Data from continuing surveys by the National Science Foundation (NSF) in the US show that federal agencies provide only 44% of the $86 billion spent on basic research in 2015 (Mervis, 2017). Pharmaceutical corporations and NIH jointly provide $26.4 billion and $27 billion, which constitute 28% and 29% of the total, respectively. Other notable contributions include other federal resources, state and local governments, medical device firms ($9.2 billion, 10% in total), biotechnology corporations ($17.9 billion, 19% in total), and other federal resources. About 3% of the money came from foundations and charities, including the Bill and Melinda Gates Foundation (Buchsbaum, 2022).

Table 1. Worldwide level of contribution and collaboration from top ten countries in intrauterine publications and insemination

SCR[a]	Country	No. of Document (%)	No. Collaborating Countries[b]
1	United States	643 (23.63%)	27
2	Turkey	175 (6.43%)	16
3	India	173 (6.36)	12
4	China	161 (5.92%)	19
5	United Kingdom	159 (5.84%)	28
6	Iran	153 (5.62%)	11
7	Netherlands	152 (5.59%)	23
8	Canada	140 (5.15%)	20
9	France	131 (4.81%)	21
10	Italy	129 (4.75%)	25

[a]SCR: standard competition ranking. [b]Number of collaborating countries with a minimum threshold of 10 documents.Result-3

The high prevalence of intrauterine insemination research in the US promotes more understanding related to infertility (Kupka et al., 2014), sperm abnormality, pregnancy (Greer and Curtin, 2006), etc. Despite having the highest number of documents in intrauterine insemination research, the US only shows two institutions with the highest number of documents in this topic. However, the low number of institutions with the highest number of documents do not affect the number of collaborating countries among US and other countries. From the results it is known that the US has the highest number of collaborating countries compared to others (Figure 2).

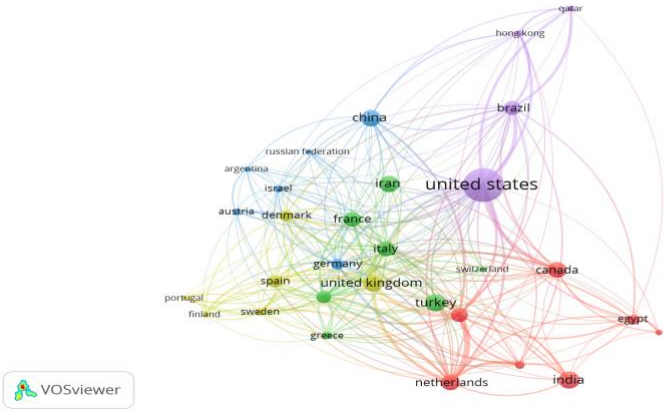


Figure 2. Mapping of collaboration among countries. Out of 160, 30 countries published a minimum of 10 documents. The amount of partnerships with other parties influences the circle's size.

Developing countries, such as India, China, and Iran were among the ten most productive countries in the field of intrauterine insemination research (Table 1). It may be caused by treatments for infertility that are inexpensive and are becoming more and more necessary in developing countries. Long before the development of in vitro fertilization, intrauterine was used as an option. But over the past 30 years, ovulation-stimulation protocols and sperm preparation techniques adapted from assisted reproductive technologies have been introduced, advancing intrauterine insemination. The success rate has not increased as much as the cost has. Because of this, researchers in developing countries have created a relatively easy-to-use intrauterine insemination technique that can be used without the use of expensive or sophisticated equipment, media, or disposable insemination catheters. It is also quite affordable and can be done by skilled personnel like nurses and midwives (Ombelet et al., 2008).

Table 2. The top ten journal in the field of intrauterine insemination

SCR [a]	Journal Title	No. of Documents (%)	Impact Factor [b]
1	Fertility and Sterility	187 (6.87%)	3.887
2	Human Reproduction	89 (3.27%)	4.865
3	Reproductive Biomedicine Online	85 (3.12%)	3.832
4	European Journal Of Obstetrics And Gynecology And Reproductive Biology	60 (2.21%)	2.213
5	Journal of Assisted Reproduction and Genetics	58 (2.13%)	2.976
5	Journal of Human Reproductive Sciences	58 (2.13%)	1.983
7	Transitional Andrology and Urology	48 (1.76%)	2.479
8	Theriogenology	45 (1.65%)	2.862
9	Gynecological Endocrinology	43 (1.58%)	2.373
10	Clinical and Experimental Obstetrics and Gynecology	39 (1.43%)	0.161

[a]SCR: standard competition ranking. There is a gap left in the rankings if two institutes have the same ranking number. [b]Science Journal Insight (SCI) 2022 was used to calculate impact factors (IF).

Based on our results, it shows that the most productive journal is *Fertility and Sterility*, which has the largest number of documents on this topic in intrauterine insemination research (Table 2). *Fertility and Sterility* was first published in 1950 with an article entitled 'Interpretation of spermatic cytology in bulls' (BLOM, 1950). The total *Fertility and Sterility* journal contributed 6.87% (n = 187) of the total documents for the last ten years taken from the Scopus database. Therefore, the journal *Fertility and Sterility* has had

little impact on the development of research related to intrauterine insemination even though the journal has published 27,179 articles from 1950 to 2022.

Table 3. The most cited articles on intrauterine insemination research

SCR [a]	Authors	Title	Article Type	Year	Journal Title	No. of Citations
1	Dunselman et al.	ESHRE guideline: Management of women with endometriosis	Article	2014	Human Reproduction	1349
2	Vercellini et al.	Endometriosis: Pathogenesis and treatment	Article	2014	Nature Reviews Endocrinology	910
3	Kadmiel and Cidlowski	Glucocorticoid receptor signaling in health and disease	Review	2013	Trends in Pharmacological Sciences	482
4	Pinborg et al.	Why do singletons conceived after assisted reproduction technology have adverse perinatal outcome? Systematic review and meta-analysis	Review	2013	Human Reproduction Update	462
5	Kupka et al.	Assisted reproductive technology in Europe, 2010: Results generated from European registers by ESHRE	Article	2014	Human Reproduction	316
5	Macer and Taylor	Endometriosis and Infertility. A Review of the Pathogenesis and Treatment of Endometriosis-associated Infertility	Review	2012	Obstetrics and Gynecology Clinics of North America	316
7	De Geyter et al.	*ART in Europe, 2014: Results generated from European registries by ESHRE*	Article	2018	Human Reproduction	288
8	Amann and Waberski	Computer-assisted sperm analysis (CASA): Capabilities and potential developments	Review	2014	Theriogenology	263
9	Aitken et al.	Reactive oxygen species and sperm function-in sickness and in health	Review	2012	Journal of Andrology	252
10	Ferraretti et al.	Assisted reproductive technology in Europe, 2009: Results generated from European registers by ESHRE	Article	2013	Human Reproduction	251

[a]SCR: standard competition ranking. There is a gap left in the rankings if two institutes have the same ranking number.

The number of citations from a research article can be used to determine the central topic of a particular field. The article entitled "ESHRE guideline: Management of women with endometriosis" is one of the most frequently cited articles (Table 3). The article was written by Dunselma et al. which was published in 2014 and comes from the Netherlands (Dunselman et al., 2014). This article was published in *Human Reproduction* and describes the optimal management of women with endometriosis based on The European Society of Human Reproduction and Embryology (ESHRE) guidelines for diagnosis and treatment. Furthermore, the topic of endometriosis treatment is also discussed in several other most cited articles on intrauterine insemination (Vercellini et al., 2014; Macer and Taylor, 2012). Therefore, it shows that discussing endometriosis treatment on the topic of intrauterine insemination is very important. In addition, importantly our bibliometric analysis also revealed that articles and reviews related to intrauterine insemination were published in leading journals on reproductive medicine such as *Human Reproduction Update* and *Human Reproduction.*

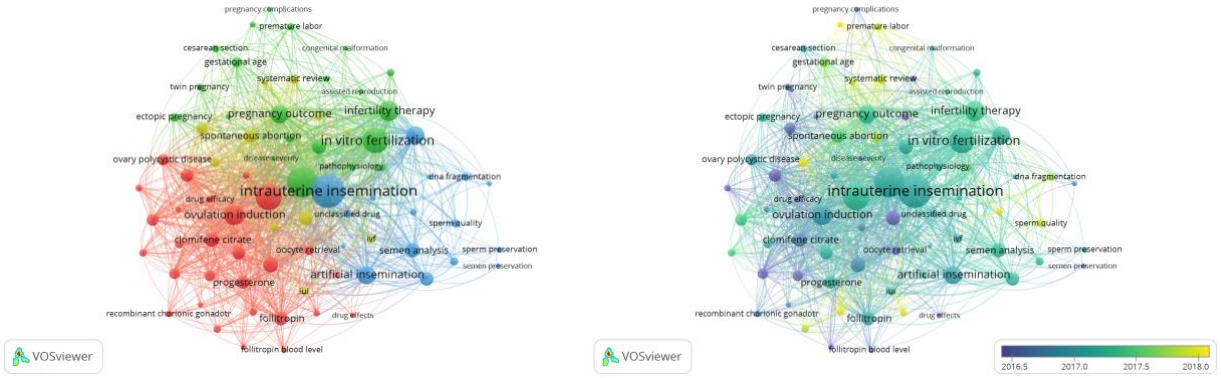
Table 4. The most prolific institution in intrauterine insemination-related publications

SCR [a]	Institution	Country	No. of Document (%)
1	Amsterdam UMC - University of Amsterdam	Netherlands	59 (2.17%)
2	University Medical Center Utrecht	Netherlands	49 (1.80%)
3	Monash University	Australia	46 (1.69%)
4	Harvard Medical School	United States	45 (1.65%)
5	Université McGill	Canada	43 (1.58%)
6	Universiteit van Amsterdam	Netherlands	42 (1.54%)
6	The University of Adelaide	Australia	42 (1.54%)
8	Amsterdam UMC - Free University Amsterdam	Netherlands	37 (1.36%)
8	Radboud University Medical Center	Netherlands	37 (1.36%)
8	Cleveland Clinic Foundation	United States	37 (1.36%)

[a]SCR: standard competition ranking. There is a gap left in the rankings if two institutes have the same ranking number.

Our results also show the total number of documents produced by ten highest prolific institution is 437 (16.06%). The most contributing institutions in literature production are Amsterdam UMC - University of Amsterdam, University Medical Center Utrecht, Monash University, Harvard Medical School, and McGill University, with percentages of 2.17%; 1.80%; 1.69%; 1.65%; and 1.58% respectively (Table 4).

Phrases found in 2721 Scopus-indexed documents about intrauterine insemination show 12291 retrieved phrases, 245 appeared more than 50 times, resulting in four unique clusters: red, blue, green, and yellow (Figure 3a). Infertility, ovulation induction, ovary polycystic disease, and chorionic gonadotropin are all terms in cluster 1 (red); pregnancy rate, in vitro fertilization, pregnancy outcome, and infertility therapy are all terms in cluster 2 (green); intrauterine insemination, artificial insemination, intracytoplasmic sperm injection, and spermatozoon motility are all terms in cluster 3 (blue); treatment outcome, spontaneous abortion, and prognosis are all terms in cluster 4 (yellow). Figure 3b shows how VOSviewer organized the retrieved phrases into a color-gradient representation of old and current publishing years, from purple to yellow. Early research on intrauterine insemination focused on a number of critical concepts, including treatment outcome, intrauterine insemination, ovulation induction, and pregnancy rate. Infertility therapy, pregnancy outcome, unexplained infertility, and fertility preservation are some of the recent growing subjects.



(a) **(b)**

Figure 3. VOSviewer mapping of terms found in titles and abstracts of research articles on intrauterine insemination. **(a)** network visualization and **(b)** overlay visualization. The size of the circles varies in direct proportion to how frequently they appear. The length of the link indicates the strength of the connection. The conditions are met by 245 out of 12291 phrases with a minimum of 50 occurrences.

Researchers from 2012 to 2017 reported various studies that discussed several basic concepts in intrauterine insemination consisting of pregnancy complications, oocyte retrieval, semen preservation, multiple pregnancies, in vitro fertilization, artificial insemination, clomiphene citrate, drug properties, classified drugs, caesarean section, ectopic pregnancy, follitropin, progesterone, and pathophysiology. Then from 2017 to 2022, the focus of research related to the topic of intrauterine insemination gradually shifted from discussion topics including treatment results, intrauterine insemination, ovulation induction, and pregnancy rates. This provides a clue about a subject that may arise in future research related to intrauterine insemination. In recent years, there has also been an increase in publications on several research subjects related to infertility therapy, pregnancy outcomes, unexplained infertility, and fertility preservation.

CONCLUSION

Publications related to intrauterine insemination research based on global bibliometric analysis over the last 10 years show an increase. Our bibliometric analysis shows that there are 10 countries with the highest number of documents, starting from the United States, Turkey, India, China, England, Iran, the Netherlands, Canada, France and Italy. The data presented from the bibliometric analysis of intrauterine insemination that we conducted can be used as an illustration of research progress in the field of intrauterine insemination every year globally. Apart from that, studies and research on intrauterine insemination can increase insight, knowledge, literature and increase the interest of researchers.

AUTHORS CONTRIBUTION

Pradnya Paramita, Vykra Aulia Firdiana, Tia Silva Norfita, and Aisha Sayidinar designed the study, analyzed the data, and wrote the manuscript. Nur Indah Septriani provided guidance, advice, and proofreading.

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CONFLICT OF INTEREST

The authors declare that there are no competing interests.

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