ISSN (Print): 0972-2467
ISSN (Online): 0976-2477
SRELS Journal of Information Management, Vol 56(2), April 2019, p. 106-111 DOI: 10.17821/srels/2019/v56i2/137318

Tracing the Trend of Research on Surrogacy: A Scientometric Analysis

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Abstract

The current work examines surrogacy-related research all over the world during the period 2007-2016. Data were obtained from the Web of Science Core Collection. Several steps were taken to identify articles on surrogacy and ultimately, any article that has the word 'surrogacy' in the paper title, abstract; author keywords and *KeyWords Plus* were identified. The process yielded 435 articles for further analysis. It was anticipated that the results would provide insight into the existing research trends and help researchers to discern the direction of science in surrogacy research in world. Such a comprehensive overview of current state of surrogacy research is important for both researchers as well as policy makers where the research is taking place.

Keywords: Research Output, SCI-Expanded, Scientometrics, Surrogacy, Web of Science.

1. Introduction

Despite over population being a major problem in India and some other countries, infertility is still a stigma (Mishra & Dubey, 2014).

Medical sciences have provided means for medically assisted human reproduction or Assisted Reproductive Technology (ART), which has altered the life of large number of infertile couples. For instance, one of every six couples of any society remnants barren and 10% of them requires the assistance of ART (Begum, 2008). ART is a group of technologies, which aid origination and pregnancy. It incorporates procedures for controlling eggs and sperms to defeat barrenness and includes numerous techniques which manipulate eggs and sperms and safeguards fertility. It includes In Vitro Fertilization (IVF), gamete intrafallopian transfer, zygote-intra fallopian transfer, surrogacy, posthumous procreation and most modern methods like Intra-Cytoplasmic Sperm Injection (ICSI), cryopreservation of donated oocyte/sperm, in vitro maturation, pre-implantation genetic diagnosis and micro sorting (Warnock, 1984).

Surrogacy was characterized in the Warnock Report as "the practice whereby one woman carries a child for another with the intention that the child should be handed over after birth (Smerdon, 2008).

There are two major types of surrogacy. i.e., Gestational surrogacy and Traditional surrogacy. In a gestational surrogacy mother is offering her reproductive labour, by leasing her womb out for a charge. In this sort of surrogacy mother is having both gestational and the organic ties with the kid. In traditional surrogacy, the surrogate mother is falsely inseminated with the sperm of the expected father or sperm donor. The surrogate's own egg will be utilized and she is considered the hereditary mother of the child (Twine, 2015).

2. Review of Literature

lenty of research has been carried out to know the research trends in an area of study. Research trends can be examined using bibliometric tools and techniques. Biradar & Thippeswamy (2004) reported a study on the Information Use Pattern by Pediatricians. Similarly, Arya & Mishra (2011) carried out a research to know the growth of literature on Bio-fuel. Thirumagal & Nehru (2015) conducted a study to know the Growth and Development of Literature on Dengue Fever.

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Baskaran & Sivakami (2014) examined research output in Swine Influenza during the period of 2006-2010. Sharma *et al.* (2017) conducted a study to know the road traffic injuries research published in India, post-1990 based on data from Scopus database.

Much research has been carried out on issues related to surrogacy, its tools and techniques, legal aspect of surrogacy However, there has been no research to identify the trends in surrogacy research, research productivity, top journals, prolific authors, top contributing countries and the most frequently cited articles. The current work is expected to provide insight into research trends in surrogacy research.

3. Methodology

Data were obtained from Web of Science Core Collection on 23 December 2017. Several steps were taken to identify surrogacy-related articles. First, the keyword 'surrogacy' was used to search for articles that were published from 2007 to 2016. The Web of Science database allows users to search keywords through Topic Search (TS). Any article that has the word 'surrogacy' in the paper title, abstract, author keywords and *KeyWords Plus* were identified. In total, 474 articles were found. Information of all the articles was downloaded into Microsoft Excel. Web of science does not allow a topic search without including KeyWords Plus which supplies additional search terms extracted from the titles of articles cited by authors in their bibliographies and footnotes (Garfield, 1990). As keywords Plus had little or no relevance to surrogacy publication so the articles that could only be searched using *KeyWords Plus* were excluded from the study. The final filter is 'front page' which contain the article title, abstract or author keywords (Fu, Wang & Ho, 2012). Ultimately, the process yielded 435 papers for further analysis.

4. Results and Discussion

In total 435 articles on surrogacy were found in SCI-Expanded from 2007-2016. 96.32% of all the articles were in English. Other languages in which papers appeared were French (2.53%), German (0.92%) and Spanish (0.23%).

5. Characteristics of Articles

Table 1 shows year-wise statistics. The average number of authors per article is found to be between 4.22 and 5.57 (overall average of 4.88). The average number of references cited by an article is 41.01. The number of surrogacy-related publications is not uniform. The total number of articles was 15 in 2007, and then the number increased to 57 in about 6 years in 2012 but showed signs of slowing down in 2013. Again, the number grew between 2013 and 2015. Table 1 also shows the average number of citations received per publication (CPP = TC2016/total publication, which is more stable and reflects the overall impact of articles). Citations during the first year or first five years fluctuate more, since some articles do not receive citations until a few years after publication (Ho, Siu & Kun-Yang, 2016; Ho & Kun-Yang, 2015). Citation frequency is correlated with the length of time since publication, and recent papers need time to accumulate citations (Gisvold, 1999). Articles published in the period 2007–2009 had the highest CPP but during 2012-2016 CPP declined every year.

Table 1. Characteristics of articles from 2007 to 2016

Years	TP	%	AU	AU/TP	NR	NR/TP	PG	PG/TP	TC2016	CPP
2007	15	3.45	81	5.4	592	39.47	147	9.8	611	40.73
2008	24	5.52	104	4.33	776	32.33	194	8.08	562	23.42
2009	27	6.21	114	4.22	1087	40.26	269	9.96	741	27.44
2010	40	9.2	176	4.4	1612	40.3	369	9.23	688	17.2
2011	44	10.11	245	5.57	1931	43.89	448	10.18	974	22.14
2012	57	13.1	292	5.12	2202	38.63	548	9.61	717	12.58
2013	43	9.89	230	5.35	2140	49.77	394	9.16	494	11.49

2014	56	12.87	252	4.5	2334	41.68	584	10.43	327	5.84
2015	69	15.86	316	4.58	2754	39.91	717	10.39	248	3.59
2016	60	13.79	321	5.35	2629	43.82	596	9.93	57	0.95
Total	435	100	2131	4.9	18057	41.51	4266	9.81	5419	12.46
Average				4.88		41.01		9.68		16.54

AU: Total number of authors; AU/TP: Average number of authors per article; NR: Number of references listed; NR/TP: Average number of references listed per article; PG: Total number of pages printed;
PG/TP: Average number of pages printed per article; TP: Total number of articles
TC2016: Total citation in 2016
CPP: Citation per publication

6. Top Subject Categories

There are 94 Web of Science categories in which surrogacy-related articles have been published. Table 2 shows top Web of Science categories in which at least 20 articles are specifically surrogacy-related publication.

Table 2. Top subject categories

Web of Science category	TP	Percent (%)	Journals (n)
Ecology	89	20.46	36
Obstetrics & Gynecology	86	19.77	28
Biodiversity Conservation	67	15.4	12
Environmental Sciences	58	13.33	13
Oncology	48	11.03	23
Reproductive Biology	42	9.66	5
Statistics & Probability	37	8.51	12
Medical Ethics	35	8.05	8
Ethics	33	7.59	7
Social Sciences, Biomedical	30	6.9	8
Mathematical & Computational Biology	29	6.67	6
Social Issues	26	5.98	5
Public, Environmental & Occupational Health	21	4.83	9

TP: Total number of articles.

Beside this, table also shows number of journals in which each of the leading subject categories lies. The leading categories were Ecology with 20.46% articles (89 of 435 articles), followed by Obstetrics & Gynecology with 86 (19.77%) articles, Biodiversity Conservation with 67 (15.4%) articles, Environmental Sciences with 58 (13.33%) articles and Oncology with 48 (11.03%) articles. There were 36 journals listed in the category of Ecology, 28 in Obstetrics & Gynecology, 23 in Oncology and 13 in Environmental Sciences.

7. Prolific Journals

Articles on surrogacy were published in a total of 36 journals. Table 3 shows the 10 most productive journals which have published not less than 10 articles during the period of 2007-2016. *Ecological Indicators* published the highest number of articles i.e. 16 followed by *Human Reproduction* with 14 papers. In terms of Impact factor, *Human Reproduction* had highest IF2016 of 5.020 which ranked second in terms of total number of surrogacy-related articles. *Ecological Indicator*, which ranked 1st in terms of its publication had IF2016 of 3.898. Ecology and Obstetrics & Gynecology ranked 1st and 2nd respectively as identified in Table 2 but in terms of subject category in which top journals figure these subject categories are in 3rd and 2nd rank respectively.

Table 3. Prolific journals

Journal	TP (%)	IF2016	Web of Science category
Ecological Indicators	16 (3.68)	3.898	Biodiversity Conservation; Environmental Sciences
Human Reproduction	14 (3.22)	5.020	Obstetrics & Gynecology; Reproductive Biology

Biodiversity and Conservation	13 (2.99)	2.265	Biodiversity Conservation; Ecology; Environmental Sciences
Reproductive Biomedicine Online	13 (2.99)	3.249	Obstetrics & Gynecology; Reproductive Biology
Bioethics	11 (2.53)	1.562	Ethics; Medical Ethics; Social Issues; Social Sciences, Biomedical
Biological Conservation	11 (2.53)	4.022	Biodiversity Conservation; Ecology; Environmental Sciences
Biometrics	10 (2.3)	1.329	Biology; Mathematical & Computational Biology; Statistics & Probability
Plos One	10 (2.3)	2.806	Multidisciplinary Sciences
Fertility And Sterility	10 (2.3)	4.373	Obstetrics & Gynecology; Reproductive Biology

%: The percentage of articles of journals in total articles; IF2016: Impact factor in 2016; TP: Total number of articles.

8. Characteristics of the Top 10 Productive Countries

A total of 56 countries contributed 435 articles on surrogacy during the period of 2007-2016. Table 4 lists the top 10 countries with at least 15 articles; the number of single-authored publication is higher than collaborative publications. USA ranked 1st with 35.88% of total publication followed by UK (16.2%), Australia (15.74%), Canada (11.81%), France (9.72%) and Italy (8.1%).

Table 4. Characteristics of the top 10 productive countries

Country	TP	TP R (P)	SP R (P)	CP R (P)	RP R (P)	SC %
USA	155	1 (35.88)	1 (28.93)	1 (14.58)	1 (27.78)	59.35
UK	70	2 (16.2)	3 (11.01)	2 (8.1)	3 (9.95)	50
Australia	68	3 (15.74)	2 (13.21)	5 (6.02)	2 (12.04)	61.76
Canada	51	4 (11.81)	4 (6.6)	3 (6.94)	4 (6.94)	41.18
France	42	5 (9.72)	5 (4.72)	4 (6.25)	5 (6.25)	35.71
Italy	35	6 (8.1)	6 (4.4)	7 (4.86)	6 (4.17)	40
Belgium	31	7 (7.18)	10 (2.2)	6 (5.56)	8 (3.01)	22.58
Germany	23	8 (5.32)	8 (2.83)	8 (3.24)	8 (3.01)	39.13
Japan	21	9 (4.86)	6 (4.4)	13 (1.62)	7 (3.47)	66.67
Netherlands	15	10 (3.47)	16 (1.26)	9 (2.55)	17 (0.93)	26.67

TP = Total number of articles; *TPR (P)* = Rank and percentage of total article; *SP R (P)* = Rank and percentage of single-authored articles; *CP R (P)* = Rank and percentage of international collaborative articles; *RP R* = Rank and percentage of corresponding-authored articles; *SC* = Single-country publication.

9. Most Frequently Cited Articles (TC2016>70)

A list of highly cited articles having not less than 70 citations since publication till the end of 2016identified 11 papers. Four of the eleven articles did not receive any citation in their publication. Four of these articles were published in the *Journal of Clinical Oncology* and 2 in *Physics of Plasma*. Both these journals do not figure in the list of most productive journals (Table 3). Figure 1 shows the year-wise number of citations of the top six articles. Except for the article by Broglio *et al*., the five see steady growth over the years (Table 5).

Table 5. Most frequently cited articles (TC2016>70)

Rank (TC2016)	Rank (C2016)	Rank (C0)	Title	References	Year
1 (233)	2 (32)	145 (0)	Detecting an Overall Survival Benefit that Is Derived From Progression-Free Survival	Broglio, Kristine R *et al.*	2009
2 (177)	5 (22)	17 (4)	Evaluation of tumor response, disease control, progression-free survival, and time to progression as potential surrogate end points in metastatic breast cancer	Burzykowski, Tomasz *et a.l*	2008
2 (177)	10 (16)	50 (2)	Prostate-specific antigen and pain surrogacy analysis in metastatic hormone-refractory prostate cancer	Armstrong, Andrew J *et al.*	2007
4 (136)	2 (32)	29 (3)	The seven impediments in invertebrate conservation and how to overcome them	Cardoso, Pedro *et al.*	2011
5 (126)	11 (14)	145 (0)	End points for colon cancer adjuvant trials: Observations and recommendations based on individual patient data from 20,898 patients enrolled onto 18 Randomized trials from the ACCENT group	Sargent, Daniel J *et al.*	2007
6 (103)	26 (9)	4 (10)	Angiographic surrogate end points in drug-eluting stent trials - A systematic evaluation based on individual patient data from 11 randomized, controlled trials	Pocock, Stuart J *et al.*	2008
7 (86)	21 (10)	9 (6)	Capsule implosion optimization during the indirect-drive National Ignition Campaign	Landen, O. L *et al.*	2011
8 (84)	4 (23)	9 (6)	Understanding global patterns of mammalian functional and phylogenetic diversity	Safi, Kamran *et al.*	2011
9 (80)	11 (14)	145 (0)	On the use of abiotic surrogates to describe marine benthic biodiversity	McArthur, M. A *et al.*	2010
10 (77)	11 (14)	145 (0)	Implosion dynamics measurements at the National Ignition Facility	Hicks, D. G *et al.*	2012
11 (73)	1 (54)	1 (19)	Circulating Tumor Cell Biomarker Panel As an Individual-Level Surrogate for Survival in Metastatic Castration-Resistant Prostate Cancer	Scher, Howard I *et al.*	2015

C2016: Number of citations in 2016; *C0:* Number of citations in the publication year; *TC2016:* Number of citations since its publication to the end of 2016.

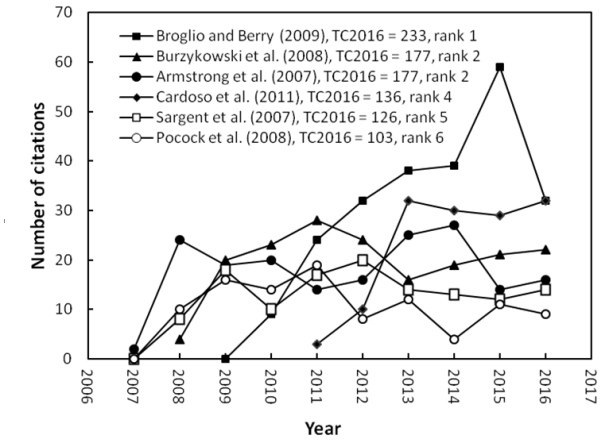

Figure 1. Citation life cycles of the top five articles (TC2016 > 100).

10. Discussion and Conclusion

Infertility is a global issue that affects millions of people worldwide. To overcome this issue, one of the techniques is surrogacy. The present study tried to examine the research output on surrogacy published during 2007-2016.

Ecological Indicators published the highest number of articles followed by *Human Reproduction*. In terms of Impact factor, Human Reproduction had highest IF2016 of 5.020 USA ranked 1st with 35.88% of total publication, followed by UK (16.2%), Australia (15.74%), Canada (11.81%), France (9.72%) and Italy (8.1%). The list of highly cited articles having not less than 70 citations, indicates that four of the eleven articles did not receive

any citation in the year of publication but picked up momentum to become leading articles by the end of 2016.

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