A small field for fertile science: the low visibility of reproductive science in high impact journals

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Abstract

Purpose Our success as a field and as individuals in reproductive science and medicine relies on our ability to produce high quality work that has broad visibility and impact. A common metric for assessing such success is the quantity of publications that are published in journals with high impact factors. It is unclear, however, how frequently work related to reproductive science and medicine actually appears in what are considered the highest impact journals.

Methods To address this gap in knowledge, we first determined how the field of reproductive biology in general compared to other research areas in terms of composite journal impact factor. Second, using a targeted search approach in the PubMed database, we examined the relationship between a journal's impact factor and the number of reproductive research articles published per journal issue.

Results We found that compared to other major scientific disciplines, our field lacks journals with impact factors above 4. In addition, primary original research articles on reproduction—irrespective of male or female search terms—do not appear often in high impact journals. Instead, there is an increased percentage of secondary reproductive literature in high impact journals compared to topic-specific journals of lower impact.

Conclusions There are likely several explanations for why reproductive science and medicine has low visibility, including the field's small relative size, its lack of a specific disease and associated strong advocacy, and its surrounding social,

ethical, and political unease. Nevertheless, there are concrete actions we can take to minimize the role of impact factor in our evaluation while simultaneously increasing influence through global awareness of the importance and need for reproductive research.

Keywords Reproduction · Impact factor · Male · Female · Gamete · Gonad · Ovary · Testis · Mammalian

Introduction

Reproductive science and medicine research influences millions of human lives daily. It serves as the basis for assisted reproduction technologies (ART), fertility preservation, oral contraceptives, prevention of sexually transmitted diseases, stem cell therapies, and beyond [1]. As a result, the most important and promising breakthroughs are tightly linked to high profile publications in high impact journals. Two such classic examples of this in the field of reproductive medicine are the work of Gregory Pincus and Robert Edwards that led to the development of the birth control pill and in vitro fertilization (IVF), respectively.

Gregory Pincus, a founding father of reproductive medicine, began his research in 1932 investigating the ovary-stimulating properties of estrogen and urine extracts of pregnant women [2]. But it was not until several years later that his research gained attention when he produced rabbits by artificial activation and identified the role of adrenal hormones in reproduction [3]. Along with colleague M.C. Chang, he synthesized progestins and found that they prevented ovulation in laboratory animals [4–6]. In 1956, this work appeared in *Science*, and Pincus began testing Enovid—the first oral contraceptive—in women in the United States, Puerto Rico, and Haiti [7]. John Rock and Miriam Menkin reported the first in vitro fertilized human egg in *Science* in 1944 [8]. Slightly later in reproductive science history, Robert Edwards began

Capsule Reproductive research is underrepresented in high impact journals.

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his in vitro manipulation of murine gametes [9]. These findings were eventually translated to human gametes due in part to the work of other scientists who developed human gonadotropins for clinical use [10]. However, it was not until 1965—when Edwards’ work on in vitro maturation of human oocytes was published in *Lancet* and *Nature*—that this branch of reproductive medicine gained significant attention among the scientific and public communities [11, 12]. This work ultimately led to the clinical development of IVF, to the birth of the first IVF baby on July 26, 1978, and to the birth of millions of children worldwide via ART [1, 13]. The importance of reproductive medicine was recognized in 2010 when Robert Edwards was awarded the Nobel Prize in Physiology or Medicine for this landmark work [14, 15].

Publication of scientific results in high impact journals such as *Science*, *Nature*, and *Lancet* is important for the visibility of any field, as work that appears in these journals is much more likely to be picked up by the media and the general public [16]. There are several methods that have been developed to measure the relative significance of a particular journal, but impact factor is currently the most generally accepted quantitative metric for determining scope and influence [16]. The impact factor is calculated as the ratio of total citations a journal receives over the preceding 2 years divided by the total number of citable articles published during that time [17–19]. The utility of the impact factor lies in its seeming simplicity: the higher the impact factor, the more significant the journal. The impact factor was devised in the 1960s as a simple aid for librarians to organize journals according to importance to their patrons, but since its inception it has evolved to dominate the research community. As a former editor of the *British Medical Journal* commented: “No other measure matters. Material that does not attract citations must be ditched, and editors must search for material and ways that will increase the impact factor of their journals” [16].

Publishing in high impact journals is not only important for a field’s visibility but also for its maintenance and growth, as it can directly impact the career success of its investigators. Journal impact factors have influenced recruitment and tenure at both academic and non-academic institutions [20]. In a study that investigated authors’ views of publishing, over 2/3 of respondents reported that journal impact factor, first authorship, and number of publications were extremely significant in their annual performance review and promotion [21]. Moreover, several governments across the globe even offer incentives for faculty not only to publish, but to publish in highly ranked international journals [22].

Despite the global importance of reproductive medicine and the need for researchers to publish their work in high impact journals, it is unclear how frequently reproductive science and medicine research actually gets published in high impact journals. To examine this question in a quantitative fashion, we took a two-pronged approach. First, we examined

how the field of reproductive biology in general compared to other research areas in terms of composite journal impact factor. Second, we examined the relationship between a journal’s impact factor and the number of reproductive research articles published per journal issue.

Materials and methods

5-year impact factor general research area analysis

We examined the 2009 5-year impact factors of journals within eight different research categories defined by the Journal Citation Report’s (JCR) database (<http://thomsonreuters.com/journal-citation-reports/>). These included: Reproductive Biology, Hematology, Endocrinology, Oncology, Immunology, Neurosciences, General & Internal Medicine, and Cell Biology. The 5-year impact factor is defined as the average number of times articles from the journal published in the past 5 years has been cited in the JCR year. Because each category contains a variable number of journals, we reported the data as a percent of journals within each research area with a 2009 5-year impact factor of < 4 and > 4. We also analyzed the aggregate impact factor for each journal category. The aggregate impact factor is calculated the same way as the impact factor, but it takes into account the number of citations of all the journals in the category and the number of articles from all journals in the category.

Journal selection and PubMed search criteria

We conducted a systematic literature search in 15 journals that ranged from reproductive-specific to general science (Table 1). For each journal, its 2009 5-year impact factor was compiled using the 2009 JCR published by Thomson Reuters (Table 1). We performed a search of the entire text of these 15 journals using clearly defined Medical Subject Headings (MeSH) within the PubMed database (Table 2). The controlled vocabulary MeSH allowed for a focused search to be performed on a particularly narrow subject of interest. Exact search terms were devised to investigate the appearance of articles regarding both female and male (mammalian) reproduction, and were limited to mice, non-human primates, and humans because these are commonly used species in mammalian reproductive research laboratories. Each search was performed using the particular journal’s National Library of Medicine identification number (NLM ID). Time limits were activated on all searches to only include articles that have been published between the years 1978 and 2010 (as of July 9, 2010). 1978 was chosen as the lower limit, for the first live birth via in-vitro fertilization occurred on July 25 of that very year; this landmark event served as the ignition to the burgeoning field of reproductive research.

Table 1 2009 5-year impact factors for select reproductive and non-reproductive journals

Journal (abbreviation)	2009 5-year impact factor	NLM ID #
Reproductive		
Molecular Reproduction & Development ^a (Mol Reprod Dev)	2.173	8903333
Reproduction ^b	3.245	100966036
Biology of Reproduction (Biol Reprod)	3.613	0207224
Fertility and Sterility (Fertil Steril)	3.961	0372772
Human Reproduction (Hum Reprod)	3.969	8701199
Non-Reproductive: Impact Factor < 15		
Developmental Biology (Dev Biol)	4.689	0372762
Development ^c	7.65	8701744
The Journal of Cell Biology (J Cell Biol)	10.121	0375356
Proceedings of the National Academy of Sciences of the USA (PNAS)	10.312	7505876
Current Biology (Curr Biol)	11.571	9107782
Non-Reproductive: Impact Factor > 15		
The Journal of the American Medical Association (JAMA)	27.753	7501160
Science	31.052	0404511
Cell	32.628	0413066
Nature	32.906	0410462
The New England Journal of Medicine (NEJM)	51.41	0255562

^a Gamete Research (1978–1988); NLM ID#: 7806559

^b Journal of Reproduction & Fertility (1960–2000); NLM ID#: 0376367. Reviews of Reproduction (1996–2000); NLM ID#: 9602351

^c Journal of Embryology and Experimental Morphology (1953–1986); NLM ID# 7906439

The numbers of published articles pertaining to female and male reproduction, and the percentage of original research articles, were tabulated from the PubMed search results (Table 3). The journals examined in this study varied widely in both their time in existence as well as in the number of issues published per year. To correct for these factors, we divided the number of published articles fitting the search criteria for a particular journal by the total number of issues for that journal since January 1, 1978 or its inception.

Results

Reproductive biology as a research area has a disparately low impact factor

To assess the relative representation of reproductive biology research within the scientific literature, we examined how the

2009 5-year aggregate impact factor of Reproductive Biology journals compared to those in other research areas, including: Neurosciences, Endocrinology, General & Internal Medicine, Immunology, Oncology, Hematology, and Cell Biology (Fig. 1). We found that the 5-year aggregate impact factor of Reproductive Biology journals was the lowest compared to the other research areas—measured at 2.69 compared to the others, which ranged from 3.88 to 5.75 (Fig. 1). In fact, when we stratified the percent of journals in each research area by impact factor, we found that the proportion of Reproductive Biology journals with low impact compared to high impact was greater than in the other research areas (Fig. 2). For example, in the field of Reproductive Biology, more than 95 % of journals have an impact factor < 4 compared to in the field of Cell Biology where approximately 33 % of the journals have an impact factor > 4 (Fig. 2).

Publication of reproductive biology research is inversely associated with journal impact factor

Because Reproductive Biology as a research area does not have any high impact journals, we wanted to investigate where reproductive biology research is published. To examine this, we performed a PubMed database search in 15 journals using defined keywords that enriched for publications on mammalian gamete reproductive biology (Tables 1, 2, and 3). For our analysis, we selected journals in three classes: a)

Table 2 Male and female search parameters using Medical Subject Headings (MeSH) within the PubMed database

Female: ((Journal ID) AND reproduction) AND (ovary OR oocytes OR ovarian follicle OR ovum) AND (mice OR humans OR primates)
Male: ((Journal ID) AND reproduction) AND (testis OR seminiferous tubules OR spermatozoa OR spermatogonia) AND (mice OR humans OR primates)

Table 3 Distribution of articles identified by search parameters in select journals

Journal	2009 5-year impact factor	# of articles published per issue [female]	% of articles: non-original research [female]	% of articles: non-original research [female]	# of articles published per issue [male]	% of articles: non-original research [male]	% of articles: non-original research [male]
Molecular Reproduction & Development	2.17	1.40	5.30	94.70	1.23	4.84	95.16
Reproduction	3.25	2.58	19.33	80.67	1.75	17.42	82.58
Biology of Reproduction	3.61	2.20	4.71	95.29	2.26	3.86	96.14
Fertility and Sterility	3.96	7.24	8.73	91.27	3.30	8.85	91.15
Human Reproduction	3.97	8.47	9.64	90.36	4.82	12.37	87.63
Developmental Biology	4.69	0.51	2.76	97.24	0.44	2.40	97.60
Development	7.65	0.35	3.51	96.49	0.28	0.74	99.26
Journal of Cell Biology	10.12	0.06	0.65	99.35	0.08	0.54	99.46
PNAS	10.31	0.16	2.44	97.56	0.20	0.00	100.00
Current Biology	11.57	0.04	6.25	93.75	0.02	25.00	75.00
JAMA	27.75	0.02	27.27	72.73	0.02	44.00	56.00
Science	31.05	0.07	44.64	55.36	0.05	39.33	60.67
Cell	32.63	0.04	15.15	84.85	0.05	14.29	85.71
Nature	32.91	0.07	38.60	61.40	0.06	35.11	64.89
NEJM	51.41	0.03	44.64	55.36	0.02	34.21	65.79

Reproductive-specific, b) Non-reproductive; impact factor < 15, and c) Non-reproductive; impact factor > 15. Of note, there were no reproductive-specific journals with an impact factor > 4 (Table 1). We were specifically interested in determining how many articles that met our search criteria were published on a per issue basis for each of the 15 journals examined. We found, as perhaps expected, that the greatest number of articles meeting our search criteria appeared in reproductive-specific journals. The number of articles

published per issue in reproductive-specific journals ranged from 1.40 to 8.47 for female search terms and 1.22 to 4.82 for male search terms. In contrast, non-reproductive journals published averages of less than 1 article/issue (Table 3; 0.136 articles/issue, female and 0.12 articles/issue, male).

This striking discrepancy in publication of reproductive articles between reproductive specific and basic science journals prompted us to examine whether a correlation existed between articles published on reproduction and a journal's

Fig. 1 The 2009 5-year aggregate impact factors of journals within eight different research categories. The 5-year aggregate impact factor of the following fields defined by the Journal Citation Report's (JCR) database were compared: Reproductive Biology, Neurosciences, Endocrinology, Internal Medicine, Immunology, Oncology, Hematology, and Cell Biology. Reproductive Biology had the lowest 5-year aggregate impact factor of the research categories examined

Fig. 2 The percent of journals with an impact factor < 4 and > 4 within eight different research categories. We stratified the percentage of journals within each research category (Reproductive Biology, Neurosciences, Endocrinology, Internal Medicine, Immunology, Oncology, Hematology,

and Cell Biology) that had a 5-year aggregate impact factor <4 from those that were >4. This analysis demonstrated that the majority of Reproductive Biology journals had a 5-year aggregate impact factor <4 compared to those in the other research categories examined

2009 5-year impact factor (IF). When the number of articles per issue is plotted against the 2009 5-year IF for each journal, a noticeable negative association regarding the publication of reproductive science is observed, regardless of whether female or male search terms were used (Figs. 3 and 4). We did not observe a direct linear correlation because *Human Reproduction* and *Fertility and Sterility*, which had respective 2009 IFs of 3.969 and 3.961, published more articles per issue than *Reproduction* and *Biology of Reproduction*, which have impact factors of 3.245 and 3.613. This finding may be due to the fact that our search terms were biased towards mammalian model organisms that will more likely appear in journals, such as *Fertility and Sterility* or *Human Reproduction*, that have a human or clinical focus. Thus, reproductive-specific journals, such as *Reproduction* and *Biology of Reproduction*, which encompass research on a broad range of model organisms, appear to publish significantly less articles per issue.

Non-original reproductive biology research is more likely to appear in higher impact journals

When we looked at basic science journals—all of which had IFs greater than 4—we found a dramatic precipice in the number of reproductive science articles published. To better understand this trend, we plotted the results for journals with an impact factor greater than 4 on a logarithmic scale (Figs. 3 and 4, insets). When we examined the data this way it revealed that, with the exception of *Cell*, the number of articles published per journal issue increased slightly in the highest impact journals examined. Interestingly, this increase in publication of reproductive-related research in the highest impact journals is unlikely to be attributed to primary original research articles. Instead over 30 % of the reproductive-related articles appearing in these journals were reviews, editorials, news,

guidelines, and commentaries (Table 3). This trend held for both female and male search terms. In contrast, in reproductive specific journals, the publication of non-original research articles was only 9 % (Table 3). Taken together, it appears that the highest impact journals are more likely to publish secondary rather than primary reproductive-related research articles.

Discussion

In this study, we examined how reproductive journals compare in influence to journals in other scientific fields, and we performed a targeted investigation of where reproductive-related research is most likely to be published. We found that compared to other major scientific disciplines (Neurosciences, Endocrinology, General & Internal Medicine, Immunology, Oncology, Hematology, Cell Biology), Reproductive Biology as a field lacks high impact journals. In addition, primary original research articles on reproduction—irrespective of sex—do not appear often in high impact journals. Instead, there is an increased percentage of secondary reproductive literature in high impact journals compared to topic-specific journals of lower impact.

There are several likely explanations for why reproductive-related research does not appear more frequently in high impact journals that appeal to a broader readership. First, the field of reproductive science and medicine is relatively small. For example, in the United States, much of the funding for reproductive research comes from the National Institutes of Child Health and Development (NICHD), and these research grants comprise only approximately 4.4 % of the entire National Institutes of Health portfolio (2012 data; <http://report.nih.gov/nihdatabook/index.aspx>). Thus, the paucity of high impact journals may merely be an unfortunate consequence of

Fig. 3 The relationship between a journal's 5-year impact factor and the number of articles published per issue containing specific female reproduction search parameters. We performed a search of the entire text of 15 journals using the following search parameters in the PubMed database: ((Journal ID) AND reproduction) AND (ovary OR oocytes OR ovarian

follicle OR ovum) AND (mice OR humans OR primates). The number of articles per issue is plotted versus each journal's 2009 5-year aggregate impact factor. The inset shows the same data plotted on a logarithmic scale for non-reproductive journals

the size of our field. Second, although reproduction is essential for life, the inability or difficulty in reproducing or maintaining endocrine function is not considered a disease. This sentiment is clearly evident in the lack of insurance coverage for infertility—both unexplained and iatrogenic—in many states [23–26]. Without a strong disease affiliation, such as in cancer, cardiovascular, and Alzheimer's research, strong advocacy and support for our discipline is lacking. Finally, there are societal, cultural, legal, and religious apprehensions that surround our field due to the

ethically charged and controversial nature of reproductive research [27–31]. Gametes and embryos, for example, have the potential to give rise to the next generation; embryonic stem cells under the right conditions can transmutate into all cell lineages; contraception prevents fertilization and implantation, and Assisted Reproduction Technologies (ART) move biological events from the body to the bench [32, 33]. Such apprehensions have unfortunately translated into federal restrictions on the funding of reproductive research—in particular research concerning human embryos.

Fig. 4 The relationship between a journal's 5-year impact factor and the number of articles published per issue containing specific male reproduction search parameters. We performed a search of the entire text of 15 journals using the following search parameters in the PubMed database: ((Journal ID) AND reproduction) AND (testis OR seminiferous tubules

OR spermatozoa OR spermatogonia) AND (mice OR humans OR primates). The number of articles per issue is plotted versus each journal's 2009 5-year aggregate impact factor. The inset shows the same data plotted on a logarithmic scale for non-reproductive journals

Such restrictions began in the 1970s shortly after the legalization of abortion and were reinforced in 1996 with the passage of the Dickey Wicker Amendment [34–36].

Although our findings are thought-provoking, it is important to highlight the limitations of our experimental approach. First, our investigation was biased because we selected a small number of journals in each category to examine further (Reproductive-Specific, General Life Sciences, IF < 15, and General Life Sciences, IF > 15) (Table 1). Second, to simplify our analysis, we performed a highly-targeted search using terms only pertaining to mammalian female and male gonads and gametes. Third, our study is based on 2009 impacts factors and the use of the PubMed as the sole reference database. Finally, it is difficult to identify an analogous scientific field in terms of size, clinical relevance, funding, and public visibility to serve as a control. Without this parallel it is difficult to know whether our findings are unique to reproductive biology research or whether there are other disciplines that share common publishing constraints. Deeper investigations are warranted to determine whether these initial findings hold true across all model organisms used for reproductive research and across all subspecialties of our broader field—ranging from endocrinology to reproductive tract biology, for example. Nevertheless, these results do raise quantifiable concerns about where our field and our work generally stands within the greater scientific community. The ramifications of this position in terms of field solidarity, maintenance of the academic pipeline, research funding, and public and policy perception are discussed further in the accompanying editorial.

The journal impact factor has inherent limitations when being used to assess scientific quality. A journal's impact factor can be heavily influenced by only a select number of highly-cited articles despite the fact that all articles within a journal are given the same credence [16]. Journals themselves can bolster their own impact factor by publishing highly controversial papers and more likely-to-be-cited review articles from larger research communities that will lead to greater citation numbers [37, 38]. Perhaps it is no surprise then that several efforts are taking place to move away from assessment using journal impact factor. For example, other rating systems have been developed, such as the Eigenfactor and Scimago Journal Rank, which attempts to reflect not only the quantity of citations a journal receives but also the quality [39, 40]. This determination is made based on a PageRank algorithm similar to what Google uses to rank websites. Another method to reduce the role of journal impact factor but to still maintain a broad impact on readership is to publish manuscripts in Open Access (OA) journals [41, 42]. The contents of OA journals are readily accessible by anyone with an internet connection, and these journals are not financed directly by the readership. However, it is still controversial as to whether or not OA journals have a similar peer-review rigor and

impact compared to subscription journals [43, 44]. Finally, there have been strong movements to eliminate journal impact factor altogether. In 2012, journal editors and publishers convened at the American Society for Cell Biology to draft the San Francisco Declaration on Research Assessment (DORA) (<http://www.ascb.org/SFdeclaration.html>). In this document, the group describes targeted guidelines for how funding agencies, institutions, publishers, and researchers can evaluate research progress without the use of journal impact factors. The ultimate goal of such guidelines is to emphasize the scientific content of manuscripts and not the impact factor of the journal where they are published. This is currently the practice of Australia's National Health and Medical Research Council where journal impact factor is completely removed from the peer review of grants and fellowships (<https://www.nhmrc.gov.au/media/newsletters/ceo/2010/nhmrc-phases-out-use-impact-factors-peer-review>).

Although journal impact factor may eventually become obsolete in ranking our productivity as individuals and as a field, there are several collective actions we can take to improve the image and position of reproductive research. To protect the shrinking pipeline of academic researchers in obstetrics and gynecology, letters could be written to tenure committees framing the field's status in relation to other disciplines to ensure that our future generation of scientists is evaluated on a level playing field. As basic scientists and clinicians, we must also develop and implement strategies to better communicate with the press, policy makers, political leaders, and the general public about the value and need for reproductive research. This is necessary so that we are poised to act on the implications of our research. There are several programs already in place to facilitate such training that would increase the impact of reproductive science independently of publishing our work in high impact journals (Fig. 5). For example, the "Reach the Decision Makers Fellowship (REACH)" supported by the Kresge Foundation and run by the University of California San Francisco's Program on Reproductive Health and the Environment is a year-long program in which scientists, health care providers, and community leaders learn how to convey the importance of reproductive environmental health to support science-based policy change at the United States Environmental Protection Agency (US-EPA). In only 3 years, REACH has trained 75 individuals nationwide and has had an impact on topics ranging from US-EPA risk assessment processes to superfund site clean up.

The Frontiers in Reproduction (FIR) course provides basic and clinical scientists in training with a broad and solid foundation in all aspects of reproductive science (Fig. 5) [45]. FIR is a rigorous 6-week program that has been held annually since 1998 at the Marine Biological Laboratory in Woods Hole, MA. There are 287 FIR alumni—40 % coming from 56 institutions within the United States and 60 % representing 42 countries from all continents except Antarctica.

Fig. 5 Programs and resources that expand the impact of reproductive science and medicine. **a** Through support of the Kresge Foundation, the Program on Reproductive Health and the Environment at University of California San Francisco runs the “Reach the Decision Makers” program (<http://prhe.ucsf.edu/prhe/REACH.html>). This program has trained 22 community members, 25 public health and clinical specialists, and 28 researchers and scientists to communicate effectively with policy makers at the US-Environmental Protection Agency. **b** The Frontiers in Reproduction (FIR) course is a 6-week intensive hands-on training course that exposes students to all facets of basic reproductive science (fir.mbl.edu). The degree distribution of FIR alumni includes: 35 % PhDs, 18 % MDs, 5 % DVMs, and 42 % advanced graduate students. **c** The Women’s Health Science Program run at Northwestern University has trained over 100 high school students in the disciplines of oncofertility

and infectious diseases (<http://womenshealth.northwestern.edu/programs/womens-health-science-program>). This educational template has been adopted by other institutions nationwide and the **d** NUBIO program which trains teachers to bring such curricula into the Chicago Public School systems (nubio.northwestern.edu). **e** Repropedia.org is a reproductive lexicon created by an international team of scientists and clinicians led by investigators at Northwestern University (www.reproedia.org). The goal of Repropedia.org is to provide the public with accessible and authoritative definitions of reproductive terminologies. The Repropedia.org site has received over 50,000 visits from global users. **f** In the current environment where impact factor is still a leading success metric, a high impact factor reproductive science journal may level the playing field and increase the visibility for our discipline

Importantly, based on a recent survey of FIR alumni (1998–2008), the majority of FIR graduates have stayed in reproductive sciences, 88 % have successfully competed for funding, and more than 70 % have published at least 5 manuscripts since completing the course (M. Ascoli, personal communication). These metrics suggest that such programs have broad impact in creating the future leaders and champions of our field.

Programs such as REACH and FIR are essential to the high visibility of reproductive research within the specialized community of scientists and clinicians. However, there are programs that also target the next generation and the general public. For example, the Oncofertility Summer Academy (OSA) is a program, run through the Women’s Health Science Program, in which high school women from underserved

communities in Chicago are selected to take part in an intense hands-on program at Northwestern University to learn the basic science and clinical medicine of reproduction through the lens of oncofertility (Fig. 5) [46]. Since OSA’s inception in 2007, 120 students have been trained by over 100 esteemed faculty using state-of-the art equipment. All of the OSA alumnae have graduated from high school and the majority are now pursuing science majors at the post-secondary level. Moreover, the OSA education template has been implemented nationwide at institutions including University of Pennsylvania, University of California San Diego, and the Oregon Health Sciences University. Finally, through a program called NUBIO, the OSA curriculum has been integrated into curricula across both private and public schools across the Chicago area.

One of the most effective methods to maximize the impact of reproductive science and medicine is to educate the general public. We have accomplished this through the creation of ReproMedia.org, a free lexicon of reproductive terminology (Fig. 5) [47]. ReproMedia.org contains authoritative and accessible text, picture, and video definitions of more than 380 reproductive terms that are reviewed by an expert editorial board. The terminology within ReproMedia.org can be incorporated and hyperlinked into any website, providing our field the opportunity to educate widely [47]. Since its inception in 2011, ReproMedia.org has received more than 53,000 visits from people spanning 183 countries and territories, indicating its global influence.

Taken together our findings suggest that the field of reproductive science, in general, lacks high impact journals and that our work does not frequently appear in the highest impact journals. There are likely explanations for these observations, including primarily the small relative size of our field. Nevertheless, we as a field can take actions to reduce the role of journal impact factor in our assessment while simultaneously making a concerted effort to broaden our impact by educating ourselves, our peers, the next generation of scientists and clinicians, and the general public on the need and value of reproductive research. Finally, our future success will most likely depend on thinking outside our reproductive science and medicine niche and instead taking part in the burgeoning field of team science [48, 49]. Interestingly, multi-university collaborations are the fastest growing type of authorship structure in almost all fields of science, and they tend to produce the highest impact manuscripts if at least one top-tier university is included [50]. Thus, participation in team science across institutional boundaries has the great potential to boost the impact of our work.

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