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Historical bibliometric analysis of the top cited articles on vesicoureteral reflux 1950–2016, and incorporation of an impact index

N. Fernandez [a,b,*], A. Puerto [b], A. Azuero [b], F. O'Kelly [c], J. Hannick [a], M. Rickard [a], A. Kirsch [d], A. Caldamone [e], M. Koyle [a]

[a]Division of Pediatric Urology, Hospital for Sick Children, Toronto, Canada

[b]Division of Urology, Hospital Universitario San Ignacio, Pontificia Universidad Javeriana, Bogota, Colombia

[c]Department of Paediatric Urology, Children's Hospital of Eastern Ontario, Ottawa, Canada

[d]Department of Pediatric Urology, Children's Healthcare of Atlanta and Emory University School of Medicine, Atlanta GA, USA

[e]Department of Pediatric Urology, Hasbro Children's Hospital, Brown University, Providence RI, USA

***Corresponding author.** Division of Pediatric Urology, Hospital for Sick Children, 555 University Avenue, Toronto, Canada.

E-mail address: Nicolas.fernandez@sickkids.ca or Fernandez.j@javeriana.edu.co (Nicolas Fernandez)

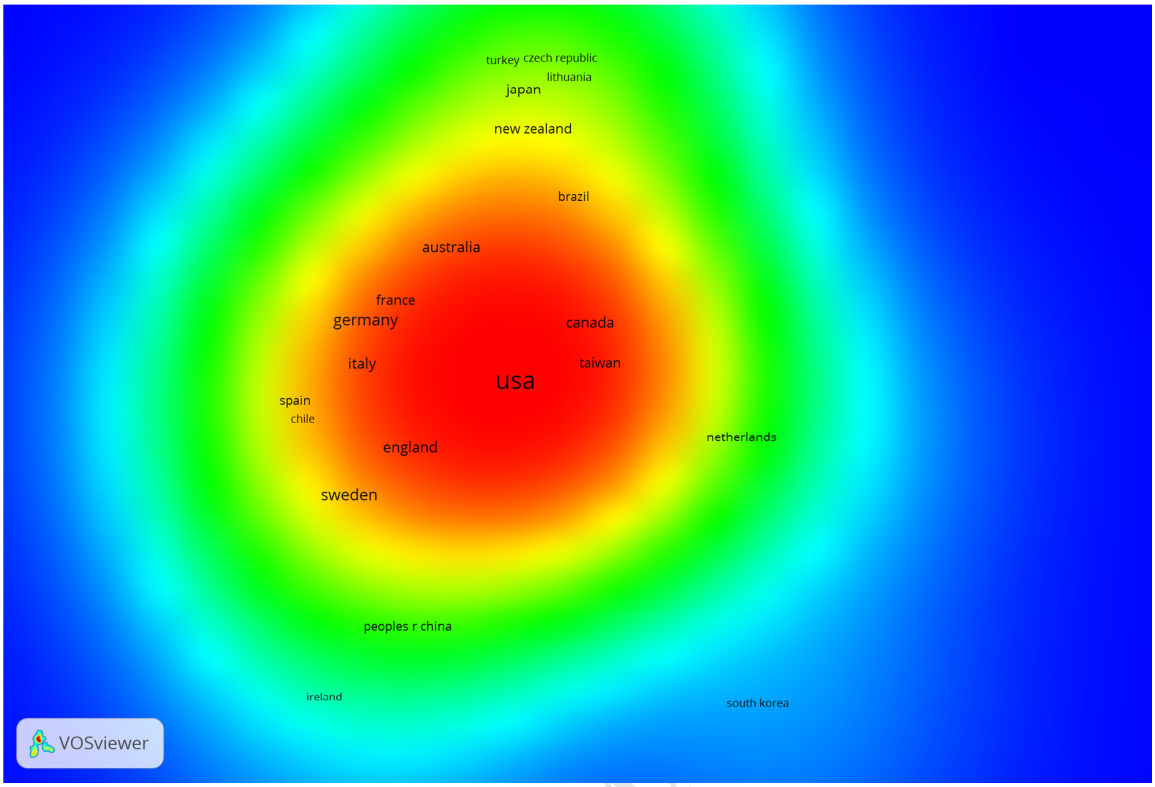
Summary

Introduction and objectives: Vesicoureteral reflux (VUR) has been one of the defining conditions unique to pediatric urology since its inception. The clinical implications of this disease process depend on intrinsic patient factors such as age, genetics, epigenetics, voiding habits, anatomic anomalies, and extrinsic factors such as the pathogenicity of infectious agents. Knowledge about its natural history, the implications of conservative and surgical management, and their associated outcomes have evolved dramatically over time. This study aimed to use bibliometric analyses to summarize the evolution of VUR management over time. In order to accomplish this, the most referenced articles for VUR since 1950 were identified, and a comprehensive analysis of their impact on the management and understanding of VUR was performed by creating a novel impact index.

Methods: A reference search was carried out for indexed citations through the portal 'Science Citation Index' in the subsection 'Web of Science Core Collection' using 'vesicoureteral reflux' as a MeSH term. References were analyzed and subcategorized according to various subtopics. A unique impact index was developed to adjust the number of publications for the time since publication, in order to define the impact of the paper amongst the most frequently cited papers. Articles were analyzed and data were tabulated according to the number of citations, country and institute of origin, journal of publication, impact factor, and first authorship.

Results: Citation counts ranged from 43–510, and the mean number of citations per publication was 101.43. The most discussed topic was ‘treatment’. The impact index showed that more recent publications have a higher impact. The author with the highest index impact had 271 citations in a period of 5 years. The top 150 articles were published across 23 countries, the majority being from the USA (Summary fig.). The most frequently cited institution had 12 publications. The journal with the highest publication referencing rate was the *Journal of Urology*.

Conclusio The most cited articles were valuable sources of information to describe the historical evolution of the pathophysiology and management of VUR. After adjusting for time since publication, the most recent publications (i.e. those published after 1990) had a higher impact index. Combining traditional bibliometric analysis with this novel impact index may allow researchers to optimize future literature analyses, while also assisting clinicians in understanding best practices for patient management based on the available literature.



Summary fig. Distribution of the 150 most cited papers about VUR worldwide 1950–2016.

Keywords: VUR; Bibliometric analysis; Impact factor

Introduction

VUR is considered one of the primary pathologies defining the subspecialty of pediatric urology. Scientists and clinicians have made great strides, over the past seven decades, towards understanding the natural history of VUR. Furthermore, diagnostic and therapeutic strategies have rapidly evolved that continue to provoke controversy amongst clinicians [1].

In 1893, Pozzi first clinically detected VUR by observing reflux from the cut end of a distal ureter when performing a nephrectomy [2]. In 1898, while working with human cadavers, Young was unable to recreate VUR when fluid was instilled into the bladder. It was not until Hutch's work in paraplegic patients demonstrating the occurrence of reflux that the importance of VUR as a clinical entity was raised. He illustrated the association between VUR and urinary infections, with a concomitant adverse effect on the kidneys, which led to a more generalized use of VCUG [3]. Over time, management strategies, although initially limited to open surgical options, have been augmented by minimally invasive options, the use of continuous antibiotic prophylaxis (CAP), and most recently by conservative observation.

Reviewing the abundance of VUR publications, the issue of redundancy becomes apparent. Results are replicated across multiple publications and peer opinion pieces yielding elevated publication importance by way of self-citation [4]. The establishment of a citation rank list has often been used in medicine to identify peer-reviewed publications that have had the greatest academic influence [5,6]. Considering the significant changes over time in the understanding and management of VUR, the current study carried out a bibliometric

analysis looking for the most cited papers on this topic, in order to generate an evolutionary description of these management trends while also evaluating the historical impact of these publications.

Methods

A comprehensive search for the most cited articles on VUR from Jan 1900 to Dec 2016 was performed, through Web of Science's basic search portal, using the MeSH term 'vesicoureteral reflux'.[a] Selected sub-categories were 'urology', 'nephrology', 'pediatrics', 'surgery', and 'genetics heredity'. The year 1950 was used as the starting point for analysis since there were no publications prior to this date, but also because historically it is the time when reflux was first considered a clinically relevant topic.

Full-text articles were accessed online and reviewed using PubMed and Ovid databases. All languages were included. Articles that did not discuss information regarding VUR were excluded. Tabulated data included the number of citations, authorship (first author), journal of publication, topic, and country, and institution of origin. Using a previously established, validated protocol, the 'cited reference search' (a component of Science Citation Index) command was used for each of these journals to identify the most frequently cited articles [7]. References were evaluated for relevance to confirm that these were manuscripts that talked about VUR as the primary topic and categorized according to the topics of natural history, diagnosis, and/or management of VUR by two independent reviewers. To perform graphical representations of retrieved data, the VOSviewer® system was used [8]. The

impact factor of journals was then cross-referenced with the 2016 edition of Journal Citation Reports (JCR): Science Edition. Based on a 2-year period, the impact factor of a journal is calculated as the mean number of citations in a year given to those papers in a journal that were published during the preceding 2 years [9].

Relying exclusively on citation count when determining the impact of a publication is subject to intrinsic limitations, as time since publication can influence these results. When it was considered that papers published earlier could have more citations simply because of the duration of time the paper was available, it was decided to adjust for this across all of the included papers. In order to understand the impact of a publication, irrespective of when it was published, a novel index was developed. This was calculated by dividing the number of years since publication by the number of citations and multiplying this by 100:

$$[\ (\frac{years\ since\ publication}{number\ of\ citations}) * 100].$$

Resulting indices demonstrated an inverse relationship, with lower indices corresponding to a higher impact. The top 150 papers were included to see if there would be changes in ranking position after applying the index analysis. All citation maps were created using free bibliometric software, VosViewer® version 1.6.6 (http://www.vosviewer.com, Leiden University, Netherlands). Statistical significance was taken as $P<0.05$ following a Student's *t*-test assessment.

Results

A total of 277 papers were identified in the original search. After excluding irrelevant and duplicate papers, the 150 most cited articles were analyzed [10]. The minimum number of citations per article was 43, and the most cited paper had 510 citations. There were 15 authors who had more than one publication in the top 150 most cited articles (Supplementary Table 1). Fig. 1 shows distribution by discussed topics. The majority of publications were dedicated to understanding treatment and pathophysiology. Manuscripts originated from 37 journals: eight urology, eight nephrology, five pediatric, three radiology, four genetics journals, and the remaining in non-surgical general medicine journals (Supplementary Table 2 and Supplementary Fig. 1). Supplementary Fig. 1 demonstrates the distribution per journal of the top 150 most cited papers. Using colors to identify when the manuscripts were published, and the size of circles to indicate the relative volume of heavily cited publications, the *Journal of Urology* clearly had most of the citations, but from older papers. More recent papers with high citation counts have been published in lesser known journals.

The most cited paper was 'An operative technique for the correction of vesicoureteral reflux' by Politano, with 510 citations (Supplementary Table 1). However, after the index analysis, this paper scored 11.4 and moved from position 1 to position 41. The paper with the highest impact adjusted for publication date was 'Urinary Tract Infection: Clinical Practice Guideline for the Diagnosis and Management of the Initial UTI in Febrile Infants and Children 2 to 24 Months' by Roberts, with 271 citations in 5 years and an index of 1.8 (Table 1). After applying the index analysis, some publications had positive, negative or no

variations in ranking positions. A total of 147 authors had a change in ranking position and three had no variation in their ranking after index analysis. There was a mean ranking variation of 75 positions per author. For the 66 papers that improved their rank after index analysis, the average rank change was 85.2 positions (P<0.001). For the papers that decreased their rank, the average change was 69.2 positions (P<0.001).

Interestingly, index analysis revealed that among the more recently published publications, the adjusted impact of publications was higher. All publications published after 1990 had a linear tendency of being more frequently cited. Older publications may have higher citation numbers, but when adjusted by the years since publication, the impact was often less than more recently published papers (Fig. 1).

Ranking of institutions based on authors' affiliations at the moment of publication showed that Harvard School of Medicine was in the first place followed by Gothenburg University (Table 2). No significant changes in ranking were seen after applying the index analysis.

Discussion

Unearthing landmark publications through the use of bibliometrics revealed how much understanding about this condition has evolved and, as a result, how different approaches to diagnosis and management have transformed alongside this. Nonetheless, it is critical to bear in mind that the most cited papers need to be carefully reviewed, considering how

many citations they have and the timeframe since publication based on the results of this novel impact index.

VUR was unknown and diagnosed systematically until the 1950s with Hutch's introduction of the concept as a clinically significant entity and Waterhouse's implementation of radiographic cystography as a method of systematic diagnosis [11,12]. Subsequent management was primarily through an open approach during the 60s and late 70s. In the 80s, minimally invasive techniques were introduced and have become widely used initial surgical treatments for VUR up to the present day [13,14]. Most recently, conservative medical management and continuous antibiotic prophylaxis (CAP) have become the first line of treatment, especially with low-grade VUR, leaving surgical correction as a fallback option in very specific cases [15]. It is important to highlight that the wide adoption of CAP has shown that VUR often spontaneously downgrades and can even spontaneously resolve as the patient ages. The majority of the papers in the current analysis reflected this evolving understanding of the etiology and pathophysiology of VUR. This progression has also been mirrored in the literature, as earlier publications focused on initial surgical management and later publications on a more conservative watchful-waiting approach [10,16-19].

The current analysis compiled the most cited papers in the field based on impact factor; however, it is clear how limited and biased this initial search may have been after viewing how these results changed after adjusting for time since publication. Although there is no proven direct correlation between citation frequency and study quality, it does offer an insight into the degree of peer analysis, readership of the manuscript, and a measure of

recognition. Similar approaches have been proposed, arguing that a reliable impact factor cannot be generated without taking into account a manuscript's publication date [20]. In the current analysis, after adjusting for time since publication, the most recent manuscripts had a greater impact than older ones (Fig. 1). Statistically significant changes in ranking positions were seen after time-adjusted index analysis was performed. This reaffirms the need to carefully interpret citation counts as a reflection of a publication's impact.

Since 1960, when Eugene Garfield created the Institute for Scientific Information and established the 'impact factor' as a tool to quantify the reputation of journals, this tool's use has quickly spread to measure individual publications [21]. Currently, a manuscript's number of citations is the most consolidated tool to measure its reputation [22]. Other citation indices, such as the H-index and iCite, have also gained popularity [23,24]. Furthermore, widespread access to the Internet, limits to the allowable number of references, and online versions of journals might contribute to some of the current analysis findings [25,26]. Access to publications on personal mobile electronic devices as well as social media may also contribute to how literature is consumed [27-30]. For example, strong correlations have been observed between tweet volume and a publication's impact factor [31]. For that reason, it would be interesting to use alternative ways to assess impact beyond the well-known impact factors that measure the influence of social media [32,33].

Recently, various social media platforms have promoted various means with which to share publications between researchers without the limitations of paid database access. This transition from traditional print journals to an open access era may alter the means through which scientific media is consumed and cited. Just as technology has seen a rapid evolution

in the digital age, the future of scientific publications will continue to evolve. As a result, now more than ever, the importance of promoting quality literary products should be stricter, limiting the influence of 'predatory journals', and incorporating a more reliable and objective means with which to perform the peer review process. 'Predatory journals' is a term coined by Beall and refers to publishers that corrupt the quality of the open-access publication process with their hunger to capture scientists to publish in their journals with doubtful peer review processes [21,34].

It is interesting to observe that after adjusting the results using the index analysis, the top five articles were published in journals not specific to urology, but with a wider reach in terms of readers. This explains the possible correlation of a better citation index if the topic reaches more specialties. Topics discussed in the top five manuscripts are of interest to specialties such as general pediatrics and family medicine. Topics that may be of more interest to pediatric urology specifically, such as surgical management, were not the aim of these top five most cited papers. For bibliometric purposes, this should be a variable to be considered at the moment of citation analysis, since very subspecialized specialties such as pediatric urology will have a smaller and more specific reader consumption than other specialties such as general pediatrics or internal medicine. On the same hand, the top five articles include the publication of guidelines, which clearly explain the reason for being the grounding for other authors on their research projects. Pediatric urology has limited research productivity of clinical trials, and two of the top five manuscripts are clinical trials.

The distribution of the majority of the most cited papers in the current analysis was amongst journals with high impact factors. Nevertheless, a considerable number of

publications originated from journals with low impact factors or from journals that are no longer in circulation. A bias to be considered is that journals with higher impact factors are more likely to be read, and publications are more likely to be about trending topics [6]. It is also important to highlight that a journal's impact factor cannot always be generalized as a good measure with which to compare journals across specialties and genres. For example, a highly specialized journal such as the *Journal of Pediatric Urology*, with an impact factor of 1.219 (2016), cannot be compared to a broader medical journal like the *New England Journal of Medicine*, with an impact factor of 33.902 (2016) [35]. Even if their impact factors differ drastically, the clinical impact of publications in such subspecialized journals may be comparable to other journals with higher and more generalizable impact within the medical community.

The majority of scientific publications on VUR have originated from North America and Europe. The current results showed the same trend. A new trend observed, however, was the significant contribution of novel perspectives from developing countries such as Turkey, Chile, and Brazil. This trend may be reflective of widespread globalization and access to the Internet [36]. Additionally, it is important to acknowledge that over the past several decades there has been exponential growth in the number of scientists and scientific journals, as well as manuscript productivity. The incorporation of scientific assistants, such as research fellows, may also have a critical impact on author productivity and manuscript citation. Future studies will yield interesting findings on how participation from more countries and varied approaches to the practice medicine will impact bibliometric analyses.

This study had some limitations. No direct evidence-based results could be concluded from the analysis. One of the drawbacks of this type of analysis is that it does not take into account that seminal papers can serve to discover new breakthroughs and talents more quickly than classical citation indices, due to the bias of self-citation, or dilution of the impact over time. Furthermore, despite providing an objective and quantitative measure of the impact of an article in its respective field, this type of analysis fails to account for self-citation and language bias. Lastly, there is an intrinsic bias in this type of research called the 'obliteration by incorporation' effect [37]. This refers to the phenomenon whereby older publications are no longer cited with the same frequency, as their findings are incorporated into the current body of literature. Due to this effect, this analysis ranked the articles based on the total number of citations received, as opposed to the number of citations received in the current year alone. Given the heterogeneity of the papers this analysis yielded, it would be challenging to correlate the type of study and impact on the medical community with purely objective conclusions. Despite these limitations, the introduction of this novel tool expands on the use of citation counts to provide the medical community with a powerful and objective measure of literature regarding VUR to illustrate the importance of each unique publication. (Supplementary Table 1).

Conclusions

The 150 most frequently cited articles on VUR are a valuable source of information for clinicians. With a condition that has changed significantly over the last several decades, using this unique impact index yielded a novel technique with which to comprehensively

assess this topic's evolution. Nevertheless, there are inherent elements of bias in citation analyses that need to be considered and further evaluated in bibliometric studies moving forward.

[a] Accessed December 2016; Institutional Access: Pontifical Xavierian University and University of Toronto.

Conflict of interest: Two of the authors are also authors of publications reviewed in this analysis. Results shown in the manuscript have not been affected by this information.

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First author	Number of citations	Impact index	Number of positions changed after index analysis
Roberts, KB	271	1.8	+6
Hoberman, A	91	2.2	+71
Garin, EH	280	3.6	+3
Bergman, DA	442	3.8	+13
Peters, CA	136	4.4	+24
Schwartz, GJ	152	4.6	+14
Sanyanusin, P	428	4.9	–4
Pennesi, M	147	5.4	+16
Roussey-Kesler, G	145	5.5	+17
Brandström, P	99	6.1	+50
Elder, JS	303	6.3	–6
Wu, XR	110	6.4	+33
Lee, RS	154	6.5	+5
Shaik, N	90	6.7	+61
Nguyen, HT	89	6.7	+64
Khandelwa, Pl	102	6.9	+38
Cheng, C	69	7.2	+75
Weber, S	136	7.4	+12
Elder, JS	134	7.5	+13
Kirsch, AJ	160	7.5	–3
Koff, SA	223	8.1	–13
Tekgul, S	49	8.2	+112
Ardissino, G	151	8.6	–1
Brandström, P	68	8.8	+70
Cherchi, SS	80	8.8	+60
Lackgren, G	169	8.9	–10

Song, R	55	9.1	+89
Jodal, U	104	9.6	+20
Weinng, L	94	9.6	+39
Geavlete, P	103	9.7	+21
Zhang, Y	81	9.9	+53
Smith, RP	48	10.4	+108
Atala, A	208	10.6	–24
Hu, P	132	10.6	0
Kirsch, AJ	119	10.9	+6
LoeningBaucke, V	174	10.9	–24
Marchini, GS	46	10.9	+110
Preda, I	82	11	+45
Skoog, SJ	53	11.3	+81
Holmdahl	53	11.3	+82
Politano, VA	510	11.4	–40
Shoskes, DA	184	11.4	–32
Hansson, S	102	11.8	+10
Rushton, HG	157	12.1	–27
Yeung, CK	150	12.7	–22
Koh, CJ	94	12.8	+20
Giannantoni, A	62	12.9	+55
Peters, CA	57	13	+62
Puri, P	99	13.1	+10
Dik, P	76	13.2	+37
Lee, EK	53	13.2	+73
Smellie, JM	135	13.3	–21
Darge, K	127	13.4	–18
Routh, JC	44	13.6	+96
Faust, WC	51	13.7	+71
Swerkersson, S	65	13.8	+41

Mallik, M	58	13.8	+51
Rushton, HG	173	13.9	–45
Kuo, HC	64	14.1	+39
Rassweiler , JJ	64	14.1	+39
Puri, P	69	14.5	+30
Ichikawa, I	95	14.7	+2
Woodward, M	92	15.2	+8
Casale, P	66	15.2	+32
Estrada, CR	46	15.2	+81
Schulte- Baukloh, H	85	15.3	+16
Pope, JC	110	15.5	–22
Rushton, HG	151	15.9	–47
Atala, A	145	15.9	–44
Yeung, CK	68	16.2	+23
Atala, A	73	16.4	+18
Coelho, GM	55	16.4	+43
Tseng, M	54	16.7	+45
Dinckan, A	48	16.7	+64
Grote, D	48	16.7	+64
Karsenty, G	53	17	+47
Weiss, R	139	17.3	–49
Bent, AE	86	17.4	+3
Stemberg, A	119	17.6	–37
Ismaili, K	68	17.6	+15
Kerecuk, L	51	17.6	+47
Piepsz, A	95	17.9	–17
Chang, SL	56	17.9	+30
Majd, M	132	18.2	–51
Lomberg, H	178	18.5	–74
Eccles, MR	92	18.5	–16

Sun, TT	54	18.5	+30
Vandersteen, DR	54	18.5	+31
Rushton, HG	100	19	–34
Gill, IS	79	19	–4
Sjostrom, S	63	19	+10
Jenkins, D	58	19	+15
Zerin, JM	120	19.2	–53
Peters, CA	46	19.3	+51
Schwab, CW	72	19.4	–5
Smellie, JM	112	19.6	–52
Hsiao, AL	51	19.6	+30
Kutikov, A	51	19.6	+31
Marra, G	61	19.7	+4
Benador, N	91	19.8	–28
Noe, HN	120	20	–62
Stokland, E	100	20	–44
Levitt, SB	173	20.2	–89
Schimmenti, LA	94	20.2	–37
Liard, A	74	20.3	–17
Perez-Brayfield, M	59	20.3	0
Majd, M	122	20.5	–69
Cardenas, DD	102	20.6	–56
Dick, PT	97	20.6	–47
Orellana, P	58	20.7	–1
Zamir, G	57	21.1	0
Kaefer, M	89	21.3	–34
Stemberg, A	60	21.7	–8
Capozza, N	63	22.2	–14
Butler, LD	48	22.9	+20
Arant, BS	108	23.1	–69

Tamminenmobius, T	104	23.1	–68
Koff, SA	142	23.2	–91
Ehrlich, RM	95	23.2	–56
Kuwertz-Broeking, E	56	23.2	–6
Noe, HN	103	23.3	–71
Mahant, S	60	23.3	–18
Feldman, AS	43	23.3	+28
Capozza, N	50	24	+7
Rosenberg, AR	100	24	–68
Lavelle, MT	45	24.4	+23
Ismaili, K	56	25	–15
Phan, V	51	25.5	+2
Aaronson, IA	89	25.8	–53
Vangool, JD	91	26.4	–56
Anderson, P	93	26.9	–62
Oswald, J	52	26.9	–7
Olbing, H	89	27	–53
Chand, DH	47	27.7	+8
Hoebeke, P	53	28.3	–14
Quek, ML	46	28.3	+12
Torres, VE	125	28.8	–101
Skoog, SJ	100	29	–82
Chertin, B	48	29.2	–2
Brophy, M	47	29.8	+1
Fugita, OE	50	30	–9
Godley, ML	49	30.6	–9
Caldamone, AA	48	31.3	–7
Herz, D	47	31.9	–1
Nuutinen, M	47	31.9	–1
Lomberg, H	97	33	–85

Dwoskin, JY	124	34.7	–110
Stephens, FD	154	35.1	–129
Tanagho, EA	117	43.6	–106
Conway, JJ	89	49.4	–73

Table 1. First author ranking and changes in rank position among VUR publications since 1950 after adjusting by impact index.

Positive changes correspond to a better ranking position. (i.e. +2 means the article improved two positions in the ranking after impact index analysis)

Institution	Number of

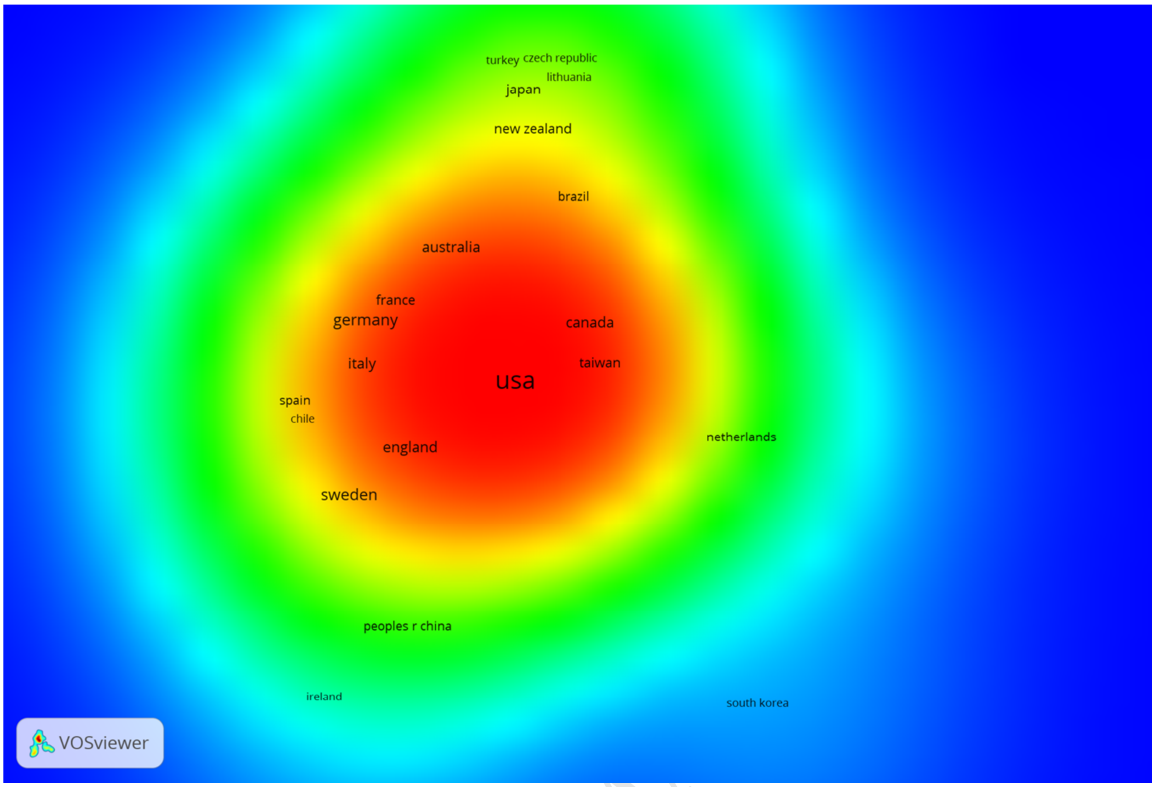
	publications
Harvard Medical School and Children's Hospital Boston	12
Götenborg University and The Queen Silvia Children's Hospital	11
Children's National Medical Center, Washington	8
Children's Healthcare of Atlanta, Emory University School of Medicine	4
The Hospital for Sick Children University of Toronto	4
New York University	4
University College Dublin and The National Children's Hospital and Children's Research Centre	3
University of Pittsburgh and Children's Hospital of Pittsburgh	3
Stanford University School of Medicine	3
University College London and Institute of Child Health London	3
Wake Forest University School of Medicine and Institute for Regenerative Medicine	3
Washington University School of Medicine	3
American Urological Association	2
Université Libre de Bruxelles and Hôpital Universitaire des Enfants-Reine Fabiola	2
University of Otago	2
Children's Hospital of Philadelphia	2
Vanderbilt University Medical Center	2
LeBonheur Children's Medical Center	2
Cleveland Clinic Foundation	2
University Children's Hospital, Uppsala	2
McGill University	2
Ohio State University Medical School and Ohio Children's Hospital	2
University of Virginia	2
Université René Descartes and Hôpital Necker-Enfants Malades	1
Saint John Emergency Clinical Hospital, Bucharest	1

Children's Mercy Hospital and Kansas University Medical Center	1
Columbia University College of Physicians and Surgeons	1
University of California	1
Department of Child Neurology, University Hospitals Leuven, Belgium	1
Department of Nuclear Medicine, Brussels	1
Childrens Hospital Melbourne	1
Department of Pediatrics, University Children's Hospital, Essen, Germany	1
Tzu Chi University and Buddhist Tzu Chi General Hospital and School of Medicine	1
Bristol Royal Hospital for Sick Children	1
University of TexasSouthwestern Medical Center, Dallas	1
Rancho Los Amigos National Rehabilitation Center, Downey	1
Federal University Of Minas Gerais and Hospital Das Clinicas, Belo Horizonte	1
St. Hedwig Hospital	1
Georgetown University School of Medicine, Washington	1
Ghent University Hospital and Paediatric Uro-Nephrologic Centre	1
Brown University and Hasbro Children's Hospital	1
Unit of Pediatric Nephrology, Dialysis and Transplantation, Department of Pediatrics, Milano, Italy	1
University College and Middlesex School of Medicine	1
Case Western Reserve University School of Medicine and Rainbow Babies and Children's Hospital, Cleveland	1
University Hospital Charles Nicolle and University Hospital Charles Nicolle	1
Greater Baltimore Medical Center	1
University of Iowa and Hospitals and Clinics, Iowa City	1
Hacettepe University	1
University of Pennsylvania and Children's Hospital of Philadelphia	1
Ha'Emek Medical Center	1
University of San Francisco	1

Catholic University of Chile	1
Chinese University of Hong Kong and Prince of Wales Hospital	1
Heidelberg University Hospital	1
Royal Liverpool Children's Hospital	1
Institute of Child Health IRCCS Burlo Garofolo	1
SLK Kliniken Heilbronn University of Heidelberg	1
IRCCS Policlinco, Matteo	1
Johns Hopkins Medical Institute	1
The Children's Hospital at Westmead	1
Chang Gung University and Chang Gung Children's Hospital	1
The Great Ormond Street Hospital for Children NHS Trust	1
American Academy of Pediatrics	1
The Institute of Child Health and Great Ormond Street Hospital for Children	1
Mayo Clinic Rochester Minnesota	1
Tulane University and Tulane University Health Sciences Center	1
UCLA Center for the Health Sciences	1
Childrens Hospital of Buffalo	1
Medical University of South Carolina	1
Mott Children's Hospital	1
Albert Einstein College of Medicine at Jacobi Medical Center	1
National Defense Medical Center Taipei	1
Children's Hospital, Geneva	1
University Medical Centre, Utrecht, and Wilhelmina Children's Hospital	1
University of Innsbruck	1
University of Nantes and Hospital Center of Nantes	1
University of Oulu	1
Westphalian-Wilhelms University of Münster	1
University of Perugia and Ospedale S. Maria della Misericordia, Perugia	1
Akdeniz University Transplantation Center, Antalya, Turkey	1
University of Rochester School of Medicine and Rochester Medical Center	1

University of South Florida	1
Oregon Health Sciences University	1
Bambino Gesù Children's Hospital	1
Ospedale Bambino Gesù	1
Prince of Wales Children's Hospital	1
Uppsala University and University Children's Hospital	1
Churchill Hospital, United Kingdom	1
Rainbow Babies and Children's Hospital, Cleveland	1
Yale University School of Medicine	1
Nottingham University Hospital	1

Table 2. Institutions of the 150 most cited papers on VUR.



Summary fig. Distribution of the 150 most cited papers about VUR worldwide 1950–2016.

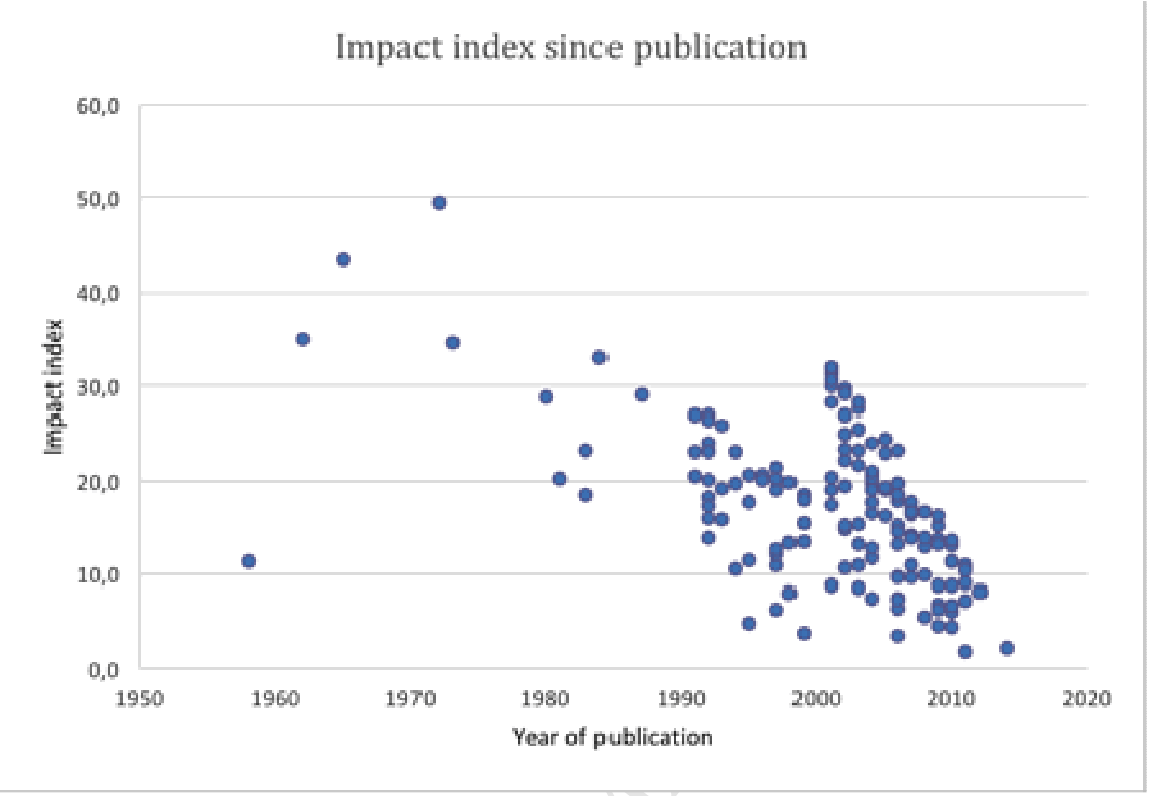


Fig. 1. Analysis of publication impact after adjusting for years since publication.

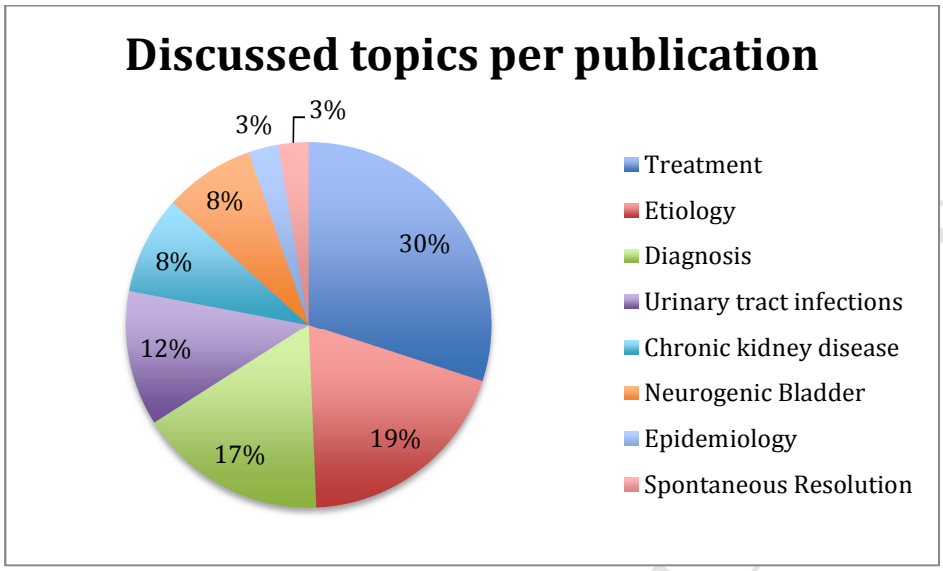


Fig. 2. Most frequently discussed subtopics among the top 150 cited papers.