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A Bibliometric Analysis and Visualisation of Research Trends in Toxicity of Implants

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Abstract
The toxicity of implants is a vital factor affecting the safety of implants. Thebibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of "toxicity of implants".All published articles related to "toxicity of implants" from "Scopus", were analyzed using the VOS viewer to develop analysis tables and visualization maps.This article had set the objective to consolidate the scientific literature regarding "toxicity of implants"and also to find out the trends related to the same.The most active journal in this research domain wasthe Brachytherapy and Journal of Biomaterials Research. The most active country was the United States of America and the leading organization engaged in the research domain was the Laval University of Canada. The most active authors were Vigneault E. and Hallab. N.J.

Keywords: Toxicity of implants,Material engineering,Bibliometric analysis, VOS viewer,

INTRODUCTION

An engineered medical device to replace a missing or damaged biological structure is known as an implant. Different types of metals and materials are used to create implants and the most popularly used metals and alloys for bio-implants are stainless steel, cobalt-chromium alloy, and Titanium[1]. Various types of implants had been used in modern medicine and include sensory implants, neurological implants, cardiovascular implants, orthopedic implants, contraceptive implants, and cosmetic implants.

Despite having various advantages associated with implants, the safety of implants is an important parameter associated with acceptance. As various metals and alloys are used as implants, the toxicity of implants and treatments to reduce implants is a serious issue to be addressed. Material engineering[2]–[4] and surface engineering [5], [6]play a vital role in the selection and usage of safe metals and alloys as implants. Several implants had been reported with issues of toxicity, the toxicity of intraocular lens implant in cases of lens-induced glaucoma [7][8]. Dental implants are more prone to toxicity and there needs a comprehensive toxicity testing programme for dental implants [9]; Nickel toxicity, due to various types of Nickel based implants[10]; toxicity of carbon fibre implants [11]; silicone toxicity associated with silicone breast implants [12][13][14][15][16]; toxicity associated in brachytherapy-treated patients of localized prostate cancer[17][18][19]; greater toxicity rate of implants based on cobalt alloys than Titanium alloys and Zirconium alloys [20]; metal toxicity due to orthopaedic implants based on Cobalt and Titanium alloys [21]; toxicity of Titanium

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compounds [22]; wear toxicity of implant metals [23][24]; Hip-implant related chorio-retinal cobalt toxicity[25]; toxicity of artificial lens implant material toward the retina[26]; toxicity of the polymer teeth implant structures for the orthopedic dentistry [27] toxicity due to implants based on cobalt-chromium alloys [28];[29]; polymer implant tissue toxicity[30]; acute cell toxicity of ceramic implant materials [31]; toxicity of plastic implants [32].The most toxic metals were identified as hexavalent Cr, Ni, and Co, in that order [33]. Nanoparticles are ideal solutions to inhibit pathogenic mechanisms by good antibacterial features and thus suitable measure againstimplant-associated pathogens [34]

This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding bio-implants. This article is arranged into four sections. The first section is the introduction, followed by the discussion of the methodology by which the research was conducted. The third section deals with results and discussion. The fourth section deals with the conclusion. The following research objectives and research questions were framed for conducting bibliometric analysis systematically.

1.1 Research Objectives

a) To consolidate the literature regarding the toxicity of implants
b) To find out the trends related to research in toxicity of implants

1.2 Research Questions

a) Who are the active researchers working on the toxicity of implants?
b) Which are the main organizations and countries working on the toxicity of implants?
c) Which are the main journals related to the toxicity of implants?

RESEARCH METHODOLOGY

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE (Toxicity Implants)on 19/01/2021. All the tables in this paper were created by using Microsoft Excel and VOS Viewer. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation.This paper had been inspired by bibliometric analysis in its presentation style, analysis, and methodology from the works [35]–[41].

RESULTS AND DISCUSSION

1.1 Results

This first round of search produced an outcome of78 documents, infivelanguages, out of which 72 documents were in English. The classification of document categories is shown in Figure 1. For improving the quality of the analysis, we had selected only the peer-reviewed articles and all other documents had not been considered. Thus after using filters “Article”and “English” the second round search produced an outcome of 64 English articles (both open access and others) andhad been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1973 had been shown in Figure 2.

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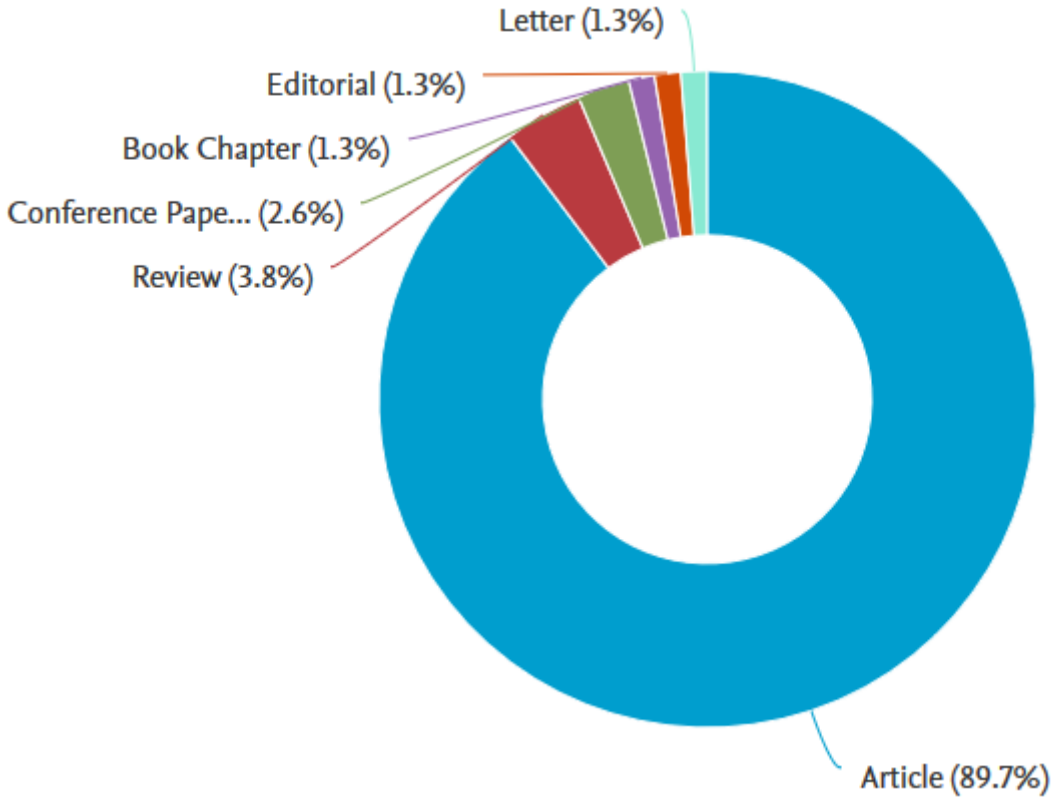

Figure 1: Classification of the documents on "Toxicity of implants", Source: www.scopus.com

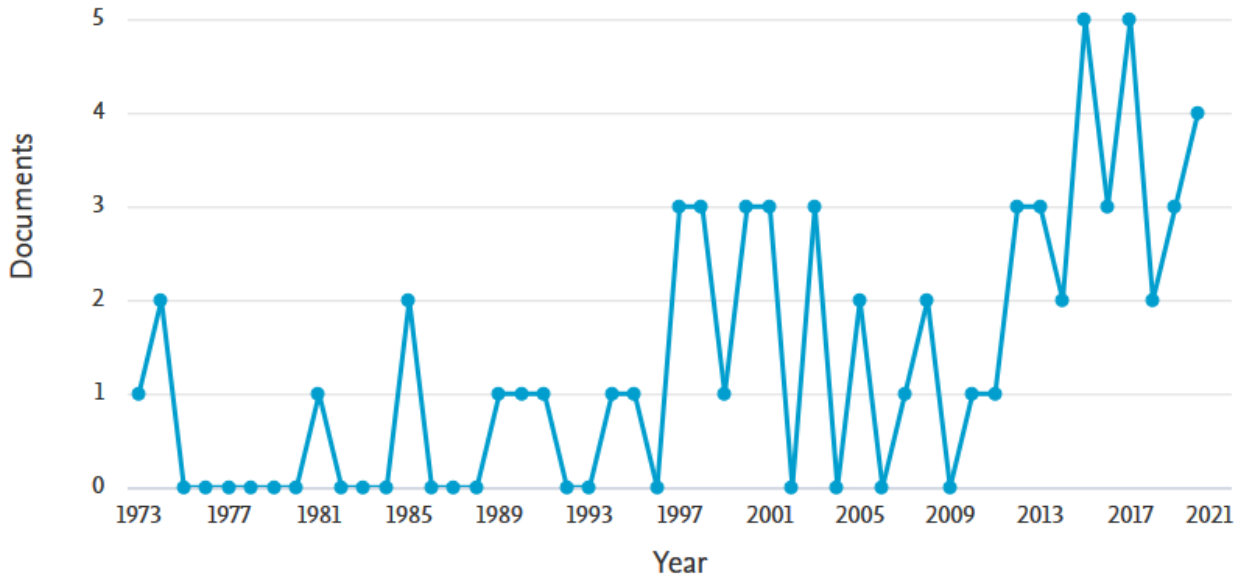

Figure 2: Period wise publication of articles, Source: WWW.scopus.com

Co-authorship analysis of top authors had been shown in figure 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as twoand the minimum number of citations of authors as one. This combination plotted the map of13 authors, in fiveclusters. The overlay visualization map of co-authorship analysis

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plotted in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.

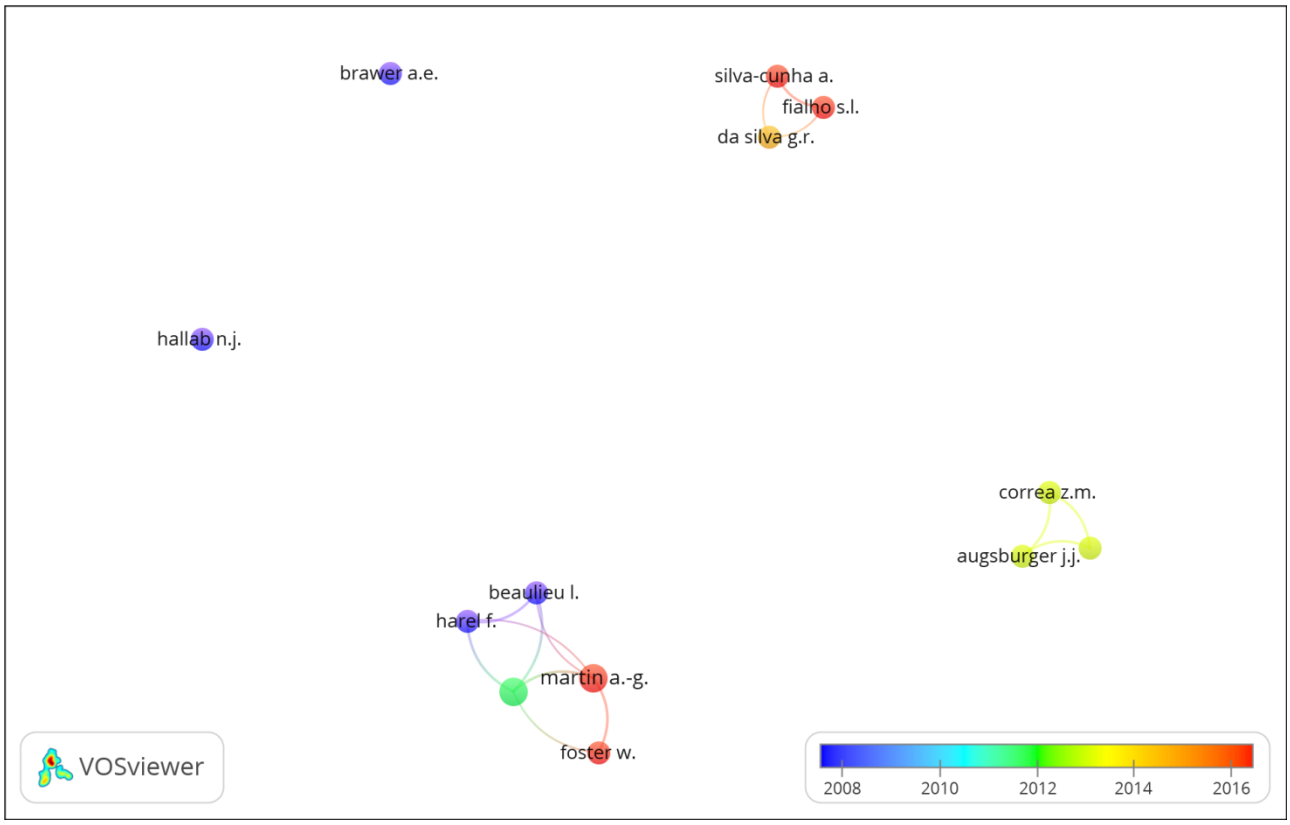

Figure 3: Co-authorship analysis on basis of authors

The citation analysis of top authors had been shown in table 1, along with co-authorship links.For the citation analysis, the parameters used were the minimum number of documents of an author as one and the minimum citations of an author as one.

Table 1: Highlights of most active authors

Description	Authors	Documents	Citations	Average citations per documents	Link strength
Authors with the highest publication and highest co-authorship links	Vigneault E.	3	44	14.6	23
Authors with the highest citations	Hallab. N.J	2	147	73.5	8

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as10. This combination plotted the map of 23thresholds, in twoclusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

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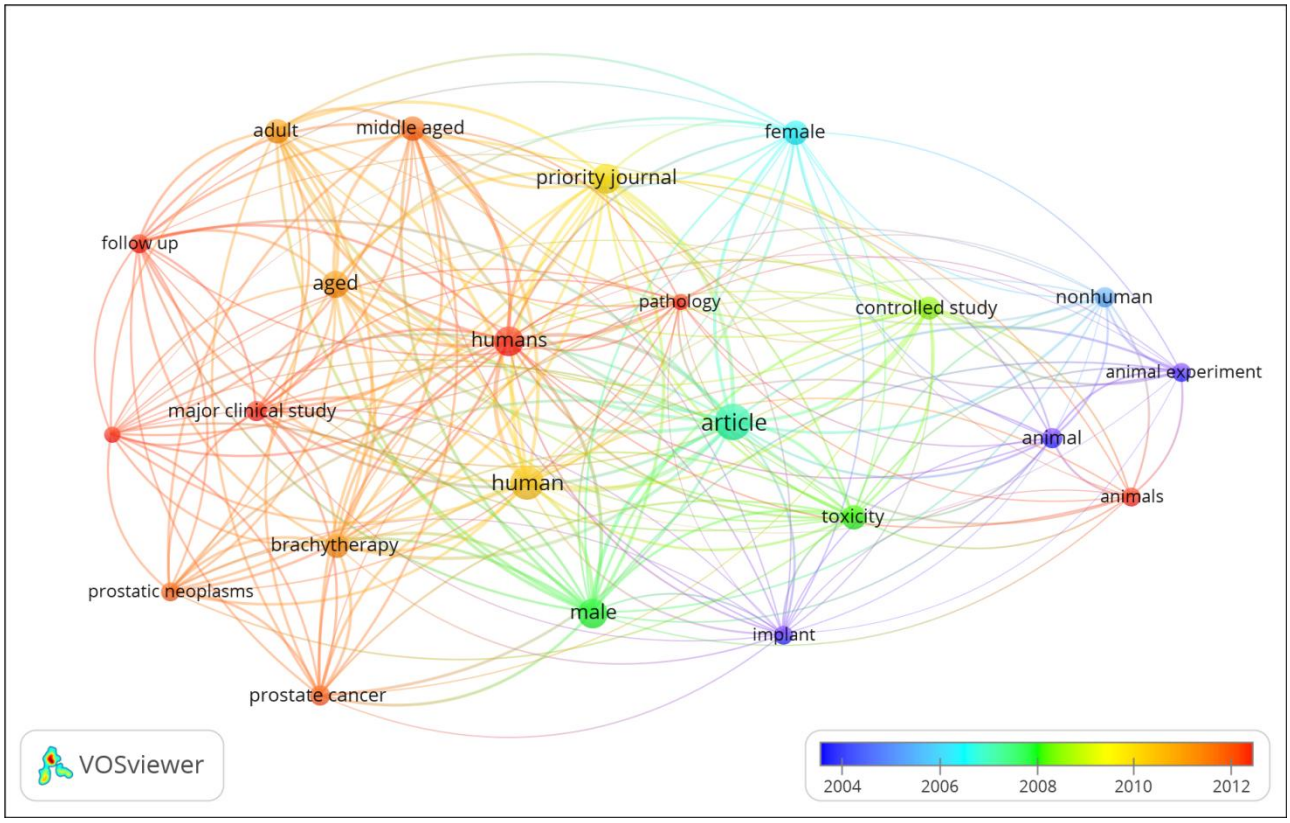

Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on “toxicity of implants” had been found out by the volume of publications and citation analysis, the parameters used are the minimum number of documents of an organization as one and the minimum number of citations of organizations as one. The leading organization in the research regarding “toxicity of implants”, with the highest number of publications and citations,was the Laval University of Canada. (Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Laval University	Canada	4	47	11.75

Co-authorship analysis of the countries engaged in the research on “toxicity of implants” had been shown in Figure 5. The overlay visualization map of co-authorship analysis plotted in Figure 5, points out the main countries with their strong co-authorship linkages and clusters involved.

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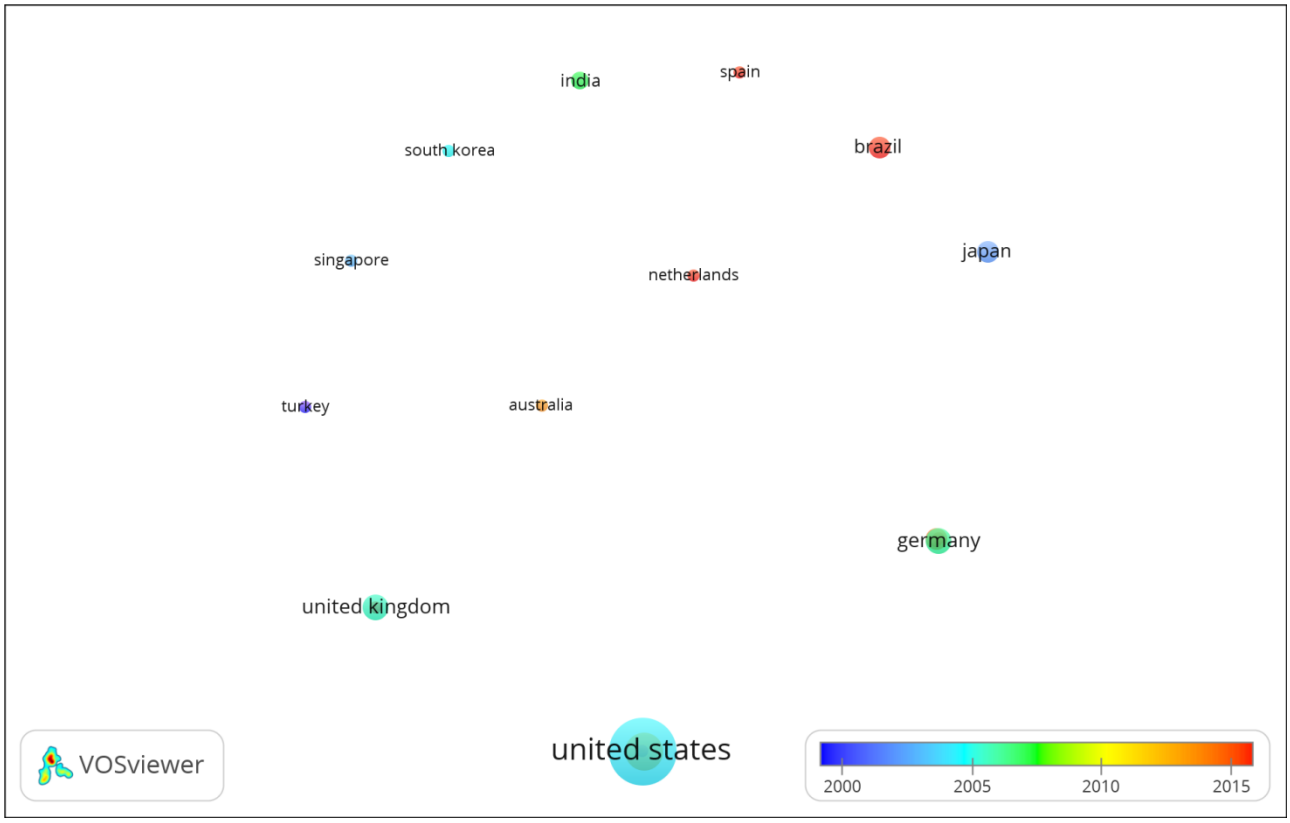

Figure 5: Co-authorship analysis on basis of countries

The citation analysis of top countries had been shown in table 3, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of acountry as one and the minimum citations of the country as one.

Table 3: Highlights of Active Countries

Description	Country	Documents	Citations	Link strength
The country with the highest publication, citations	United States of America	28	461	2

The most active country in this research domain was the United States of America, with the highest number ofpublications, and citations.

Link analysis and citation analysis were used to identify the most active journal in this research domain. We have taken the parameters of the minimum number of documents of a journal as one and the minimum number of citations of a journal as one for the link analysis and citation analysis. Highlights of the most active and relevant journals related to “toxicity of implants”are shown in table 4. Table 4shows the journal activity of this research domain through parameters of publication volume, citations, and co-authorship linkages.

Table 4: Analysis of journal activity

Description	Journal details	Documents	Citations	Average citations per

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				documents
Journal with the highest publications	Brachytherapy	7	87	12.4
Journal with the highest citations	Journal of Biomaterials Research	2	159	79.5

From the above discussion regarding the bibliometric patterns in the research regarding "toxicity of implants",this research had observed a gradual increase in research interest regarding "toxicity of implants"from the starting of the millennium and the momentum is going on positively.This points out the relevance and potential of this research domain (Refer to Figure 2).The most active authors in this research domainwere Vigneault E. and Hallab. N.J with the highest publication and co-authorship links; and citations respectively(Refer to table 1).The overlay analysis of top countries researching "toxicity of implants"indicates that the United States of America was the leading countryrelating tothe highest numberof publications, citations, and co-authorship links(Refer to figure 5). The top journal of this research domain was identified as the Brachytherapy and Journal of Biomaterials Research.Fromthese wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding the toxicity of implants.

CONCLUSION

Toxicity of implants was an interesting research domain and the most active journals related to this research domain were the Brachytherapy and Journal of Biomaterials Research.The most active countrywas the United States of America.The leading organization engaged in the research regarding the "toxicity of implants" was the Laval University of Canada. The most active authors who had made valuable contributions related tothe toxicity of implantswere Vigneault E. and Hallab. N.J with the highest publicationand co-authorship links; and citations respectively.This research domain offers a new avenue for researchers and future research can be on innovations in toxicity of implants.

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