This study aimed to determine the number and quality of scientific publications in dentistry from the Baltic countries of Lithuania, Latvia, and Estonia between 1996 and 2018 using bibliometric analysis. Web of Science and Scopus were searched to identify scientific publications in dentistry between 1996 and 2018 by authors from centers in Lithuania, Latvia, and Estonia. The annual number of scientific publications, citation rate, and h-index for each publication, and trends in international co-authorship were investigated by country and institution.

There were 651 scientific publications in dentistry between 1996 and 2018, by authors from Lithuania (280 publications), Latvia (210 publications), and Estonia (161 publications). Publications from Estonia were ranked highest in qualitative terms (citation rate and h-index), followed by Lithuania, and Latvia. Of 28 authors with at least ten publications, 54% were Lithuanian (15 authors), 25% were Estonian (7 authors), and 21% were Latvian (6 authors). Estonian authors collaborated mainly with Finland (27 publications), Latvian authors with the USA (16 publications), and Lithuanian authors with Canada (26 publications). Most publications came from the academic institutions of the Lithuanian University of Health Sciences (136 publications), the University of Tartu (109 publications), Vilnius University (101 publications), and Riga Stradins University (28 publications). During the past 22 years, authors from Lithuania had the most publications in the field of dentistry, and authors from Estonia had the most cited publications. Authors mainly published in native journals and collaborated with authors in Scandinavia and North America.

**MeSH Keywords:** Baltic States • Bibliometrics • Dentistry • Estonia • Latvia • Lithuania
Background

Twenty-seven years ago, the Baltic countries of Lithuania, Latvia, and Estonia restored their independence from the Soviet Union. During this time, five main academic centers began to train dental specialists and undertook and published scientific research in the Baltic countries and included the Lithuanian University of Health Sciences and Vilnius University in Lithuania, the University of Latvia and Riga Stradins University in Latvia, and the University of Tartu in Estonia. A sufficient period has now passed to evaluate the quantity and quality of scientific publications in dentistry in the three Baltic countries.

In 1987, Broadus defined bibliometrics as, ‘the measurement of patterns in written communication’ [1]. Bibliometrics now involves not only the evaluation of patterns of publications and citations, but also the assessment of variables that include the number of publications and citation from each author, research group, or institution [2]. Bibliometric methods have previously been used in the health sciences, including medicine and dentistry [3]. Scientific publications are indicators of important areas of research and show research trends and output by individual authors, research groups, academic centers, and countries [4]. Bibliometric studies can assess scientific performance and are used to provide objective information for planning research and development programs, allocation of research funding, and for optimizing resources and materials to support the scientific community.

Scientific impact indicators are used to evaluate the quality of the publications in biomedical journals according to the number of times the publications are cited and the quality of the publications. Basic research impact indicators include citation analysis of the impact or quality of an article assessed by the number of times the publication is cited. The h-index measures both the productivity and the impact of citations of the publications of an author [5,6]. However, although the h-index has some limitations, it can be complemented by other indices, including the g-index that quantifies productivity in science based on the number of publications [7], and the hg-index [8], that combines both measures [9].

The second type is impact indicator reflects the journal that the author publishes in. Worldwide, the most used index of journal quality is the journal impact factor (IF) [10]. The IF has been the most important factor in assessing the quality of journals for several decades. However, alternative indicators of journal quality are used, including the SCImago Journal Rank (SJR) indicator [11], and the Source Normalized Impact per Paper (SNIP) [12]. It is important that the appropriate use of impact measures be used and that their limitations are recognized, as these indicators have a direct impact on the author and academic performance measures and in the allocation of research funding [13].

Web of Science and Scopus are important sources for citation data, and the interdisciplinary coverage of these databases represents a significant strength for the study and comparison of different scientific fields, including dentistry [14]. Currently, multidisciplinary and international bibliometric analysis and the coverage from these individual databases can vary between countries, which may introduce some bias when performing comparative analysis [15]. Therefore, the combined use of Scopus and Web of Science was chosen to identify publications in the field of dentistry in this bibliometric study.

To our knowledge, no previous bibliometric studies have evaluated the research output in dental sciences in terms of publications from the Baltic countries. Therefore, this study aimed to determine the number and quality of scientific publications in dentistry from the Baltic countries of Lithuania, Latvia, and Estonia between 1996 and 2018 using bibliometric analysis.

Material and Methods

Information sources

Two databases were selected to analyze the publications, the Web of Science (Clarivate Analytics) and Scopus (Elsevier). The study investigated publications from 1996, the first year when Scopus data could be accessed, and included all publications until 2018.

Types of publications

There were no restrictions regarding the types of publications, but Ph.D. and other theses or dissertations were excluded. No restrictions regarding the language of the publications were applied.

Search strategy

An advanced search strategy was used. The keywords used to search the two databases were: lithuania, or lietuvas republika, or lietuva, or, republic of lithuania, or lt, and dent, or all Medical Subject Heading (MeSH) terms associated with dentistry. Latvia, or latvija, or republic of latvia, or lv, and dent, or all MeSH terms associated with dentistry. Estonia or eesti, or republic of Estonia, or ee, and dent, or all MeSH terms associated with dentistry.

The choice of keywords was intended to be broad, to collect as much relevant data as possible without relying on electronic means alone to refine the search results.
Selection of studies

The identified publications were independently reviewed by two reviewers to verify their eligibility for inclusion in the bibliometric evaluation. Publications associated with dental research only were included. Reviewers resolved any differences in journal selection by discussion and consensus, with the inclusion of a third-party opinion when consensus could not be reached. The country of origin of the publications was identified using multiple count analysis and each publication was assigned to a country identified from the details of the authors.

Sequential search strategy

The bibliometric analysis was conducted in several stages. First, the annual scientific output over the period for each Baltic country was established. Then, the most productive authors and institutions were identified. To identify the most productive authors, the different forms of the author names and their ORCID identifiers were used, where applicable. Collaborating countries and institutions were also identified. The bibliometric indicators included the total number of publications, authors, institutions, the number of citations, the citing publications, the average citations per publication, with and without self-citation, were identified using the h-index, g-index, and hg-index.

Synthesis of the results

Relevant data of the bibliometric variables were collected and organized into tables, according to the Baltic country of authorship. The tables included results according to the most productive countries, institutions, journals, authors, and bibliometric indices.

Results

Quantitative and qualitative bibliometric data for publications in dentistry

The results of this study showed that that over the period between 1996–2018, a total of 651 scientific publications in dentistry were identified for the three Baltic countries of Lithuania, Latvia, and Estonia (Table 1). Lithuania was ranked highest in quantitative terms (280 publications), followed by Latvia (210 publications), and Estonia (161 publications). Estonia was ranked highest in qualitative terms (number of citations, h-index, g-index, and hg-index), followed by Lithuania, and Latvia.

The annual number of scientific publications for each country is presented in Figure 1. There was an increase in the number of publications from 1990. During the period between 1996–2006, all three Baltic countries showed a similar publication rate.
However, in 2007 the number of publications in dentistry from Lithuania started to increase, and in the last five years have remained at almost twice the number compared with those from Latvia and Estonia.

**Bibliometric data on authors of publications in dentistry**

The most productive authors from each country, who had published at least ten publications between years 1996–2018, were investigated in detail and bibliometric indices were counted. There were 28 authors (Table 2), of which 54% were Lithuanian (15 authors), 21% were Latvian (six authors) and 25% were Estonian (seven authors). The most productive author (Lukevics E) had a total of 463 publications, followed by an author (Metspalu A) with 345 publications, and an author (Zharkovsky A) with 131 publications. A qualitative analysis of the h-index ranked the authors, and showed one author (Metspalu A) in first place with an h-index of 60, followed by an author (Lukevics E) with an h-index of 26, and an author (Zharkovsky A) with an h-index of 22. The University of Tartu had the highest number of publications (seven publications). The Latvian Institute of Organic Synthesis, Vilnius University, and Lithuanian University of Health Sciences had publications from six authors in the list, whereas Vilnius Implantology Center had publications from two authors, and the University of British Columbia had a publication from one author.

**Bibliometric data of publications in dentistry by country**

Each Baltic country was analyzed individually to assess most productive authors, institutions, and collaborative countries in terms of the numbers of publications and their citations (Tables 3–5). Estonian authors had 96 collaborative publications with other countries, Latvian authors had 57 international collaborative publications, and Lithuanian authors had 53 international collaborative publications. Estonian authors most frequently collaborated with authors in Canada (26 publications), Finland (21 publications), and the USA (20 publications). Authors in all three Baltic countries tended to collaborate with each other. Collaboration between Latvian and Estonian authors included ten publications. Collaboration between Latvian and Lithuanian authors included nine publications. Collaboration between Lithuanian and Estonian authors included four publications.

**Bibliometric data of publications in dentistry by institution**

The most productive institutions in all three Baltic countries were universities that trained dental specialists. The University of Tartu in Estonia had 109 publications (68% of all Estonian publications). Riga Stradins University in Latvia had 28 publications (13% of all Latvian publications) and the University of Latvia had 23 publications (11% of all Latvian publications). The Lithuanian University of Health Sciences had 136 publications (49% of all Lithuanian publications), and Vilnius University had 101 publications (36% of all Lithuanian publications).

Technical universities in each country had significant numbers of publications. Tallinn University of Technology had 12 publications, ranking 3rd for the number of publications in Estonia. Riga Technical University had 11 publications, ranking 5th for the number of publications in Latvia. Kaunas University of Technology had 17 publications, ranking 4th for the number of publications in Lithuania. Private institutions were ranked lowest on scientific output and bibliometric indices, except for the Vilnius Implantology Center that had 16 publications and was ranked 6th for the number of publications in Lithuania.

**Bibliometric data of publications in dentistry by journal**

Authors from the three Baltic countries submitted publications to different types of journals. Estonian authors published scientific research in journals that included *European Neuropsychopharmacology* (eight publications), *Molecular Brain Research* (five publications), and the *European Journal of Neuroscience*. Latvian authors published scientific research in journals that included the *British Journal of Dermatology* (five publications), the *Journal of the American Academy of
Table 2. Qualitative and quantitative evaluation of the publications of the authors with at least ten or more publications in dentistry in the Baltic countries Lithuania, Latvia, and Estonia between 1996 and 2018.

| Author                | Affiliation                               | Total publications | h-index | g-index | hg-index | Country  |
|-----------------------|-------------------------------------------|--------------------|---------|---------|----------|----------|
| Edmunds Lukevics      | Latvian Institute of Organic Synthesis    | 463                | 26      | 39      | 31       | Latvia   |
| Andres Metspalu       | University of Tartu                       | 345                | 60      | 147     | 93       | Estonia  |
| Alexander Zharkovsky  | University of Tartu                       | 131                | 22      | 38      | 28       | Estonia  |
| Edgars Abele          | Latvian Institute of Organic Synthesis    | 103                | 16      | 19      | 17       | Latvia   |
| Juris Popelis         | Latvian Institute of Organic Synthesis    | 102                | 14      | 20      | 16       | Latvia   |
| Pavel Arsenyan        | Latvian Institute of Organic Synthesis    | 98                 | 14      | 21      | 17       | Latvia   |
| Kira Rubina           | Latvian Institute of Organic Synthesis    | 84                 | 13      | 24      | 17       | Latvia   |
| Jolanta Aleksejuniene | University of British Columbia            | 81                 | 13      | 22      | 16       | Lithuania|
| Gintaras Juodzbalys   | Lithuanian University of Health Science   | 67                 | 14      | 22      | 17       | Lithuania|
| Edvitas Leibur        | University of Tartu                       | 51                 | 12      | 22      | 16       | Estonia  |
| Vita Maciulskiene     | Lithuanian University of Health Sciences  | 48                 | 15      | 30      | 21       | Lithuania|
| Irena Balcuniene      | Vilnius University                        | 48                 | 9       | 24      | 14       | Lithuania|
| Ricardas Kubilius     | Lithuanian University of Health Sciences  | 43                 | 11      | 16      | 13       | Lithuania|
| Vytaute Peciciule     | Vilnius University                        | 42                 | 9       | 24      | 14       | Lithuania|
| Alina Puriene         | Vilnius University                        | 41                 | 7       | 15      | 10       | Lithuania|
| Mare Saag             | University of Tartu                       | 36                 | 13      | 19      | 15       | Estonia  |
| Kulli Jaako Movits    | University of Tartu                       | 36                 | 9       | 18      | 12       | Estonia  |
| Antanas Sidlauskas    | Lithuanian University of Health Sciences  | 35                 | 9       | 16      | 12       | Lithuania|
| Ilze Akota            | Latvian Institute of Organic Synthesis    | 32                 | 6       | 11      | 8        | Latvia   |
| Tomas Linkevicius     | Vilnius Implantology Center               | 30                 | 14      | 26      | 19       | Lithuania|
| Alvysdas Gleiznys     | Lithuanian University of Health Sciences  | 29                 | 4       | 7       | 5        | Lithuania|
| Vilma Brukiene        | Vilnius University                        | 25                 | 6       | 9       | 7        | Lithuania|
| Diana Mieliuksaitė     | Vilnius University                        | 24                 | 5       | 8       | 6        | Lithuania|
| Laura Linkeviciene    | Vilnius University                        | 22                 | 7       | 16      | 10       | Lithuania|
| Tamara Zharkovskaya   | University of Tartu                       | 22                 | 9       | 17      | 12       | Estonia  |
| Julija Narbutai       | Lithuanian University of Health Sciences  | 20                 | 7       | 13      | 9        | Lithuania|
| Algirdas Puisys       | Vilnius Implantology Center               | 20                 | 12      | 23      | 16       | Lithuania|
| Triin Jagomagi        | University of Tartu                       | 17                 | 8       | 15      | 10       | Estonia  |
Table 3. Scientific publications in dentistry from Estonia according to international collaborations by country, institution, and journal between 1996 and 2018.

| Countries | Records | Institutions                      | Records | Journals                                      | Records |
|-----------|---------|------------------------------------|---------|-----------------------------------------------|---------|
| Estonia   | 148     | University of Tartu                | 109     | European Neuropsychopharmacology               | 8       |
| Finland   | 27      | University of Helsinki             | 13      | Journal of Dental Research                     | 7       |
| Sweden    | 23      | Karolinska Institute               | 12      | Acta Odontologica Scandinavica                 | 6       |
| USA       | 19      | Tallinn University of Technology   | 12      | Brain Research Molecular Brain Research        | 5       |
| Germany   | 17      | University of Turku                | 12      | Caries Research                                | 5       |
| England   | 11      | Tartu University Hospital          | 9       | Bulgarian Chemical Communications              | 4       |
| Norway    | 11      | Estonian Biocenter                | 8       | Microbial Ecology in Health and Disease        | 4       |
| Latvia    | 10      | National Institute of Chemical     | 7       | Applied Radiation and Isotopes                 | 3       |
| France    | 9       | University of California          | 6       | European Journal of Neuroscience               | 3       |
| Netherlands | 9    | University of Oslo                | 6       | Oral Surgery Oral Medicine Oral Pathology Oral Radiology | 3 |

Table 4. Scientific publications in dentistry from Latvia according to international collaborations by country, institution, and journal between 1996 and 2018.

| Countries | Records | Institutions                      | Records | Journals                                      | Records |
|-----------|---------|------------------------------------|---------|-----------------------------------------------|---------|
| Latvia    | 145     | Riga Stradins University           | 28      | Proceedings of The Latvian Academy of Sciences Section B Natural Exact and Applied Sciences | 16      |
| USA       | 16      | Latvian Institute of Organic Synthesis | 23      | British Journal of Dermatology                | 5       |
| England   | 14      | University of Latvia               | 23      | Journal of The American Academy of Dermatology | 5       |
| Germany   | 12      | Latvian Biomedical Research Study Centre | 11      | Papers on Anthropology University of Tartu   | 5       |
| Estonia   | 10      | Riga Technical University          | 11      | Research for Rural Development                | 5       |
| Switzerland | 9     | Russian Academy of Medical Science | 8       | Acta Dermato Venereologica                    | 4       |
| Lithuania | 9       | Children’s Clinical University Hospital Riga | 6       | Khiymiya Geterotsiklicheskikh Soedinennii      | 4       |
| Russia    | 8       | Latvian Academy of Sciences        | 6       | Metal Based Drugs                             | 4       |
| Finland   | 7       | University of Tartu                | 5       | Official Gazette of The United States Patent and Trademark Office Patents | 4 |
| Sweden    | 7       | Latvia University of Agriculture   | 4       | Allergy                                       | 3       |
Table 5. Scientific publications in dentistry from Lithuania according to international collaborations by country, institution, and journal between 1996 and 2018.

| Countries | Records | Institutions | Records | Journals | Records |
|-----------|---------|--------------|---------|----------|---------|
| Lithuania | 258     | Lithuanian University of Health Sciences | 136     | Medicine Lithuania | 31      |
| Canada    | 26      | Vilnius University | 101     | Clinical Oral Implants Research | 13      |
| Finland   | 21      | University of British Columbia | 21      | Medical Science Monitor | 12      |
| USA       | 20      | Kaunas University of Technology | 17      | Journal of Dental Research | 10      |
| Germany   | 17      | Aarhus University | 16      | Caries Research | 8       |
| Denmark   | 16      | Vilnius Implantology Center | 16      | Elektronika ir Elektrotechnika | 7       |
| Norway    | 15      | University of Oslo | 14      | Mechanika | 7       |
| England   | 10      | State Research Institute Centre for Innovative Medicine | 11      | Implant Dentistry | 6       |
| Italy     | 9       | University of Michigan | 11      | Dental Materials Journal | 5       |
| Latvia    | 9       | University of Oulu | 11      | European Journal of Dental Education | 5       |

Discussion

To our knowledge, this is the first study to quantify and analyze all electronically available scientific publications from authors in the field of dentistry in the Baltic countries of Lithuania, Latvia, and Estonia. In 2012, Petrauskiene reported the findings from a survey on the need for bibliometric analysis of publications from Vilnius University in Lithuania in which 80% of the respondents agreed that such analysis was required [16]. In 2003, Allik performed a general bibliometric analysis of scientific publications in the Baltic countries after the first decade of independence [17]. This author concluded that Estonian and Lithuanian scientists had more than doubled the number of journal publications as indexed by the Web of Science (formerly, the ISI Web of Knowledge), while the number of publications from Latvia had increased by 10%. In 2008, analysis of all publications between 1997–2007 indicated that Lithuania showed improvement in the quality of scientific publications, Estonia increased the impact of its publications, and the impact and quality of publications in Latvia remained the same [18]. These results are also reflected by a similar relationship in the field of dental publications that have shown an increased number of publications in dentistry from Lithuania and improved the quality of publications in dentistry from Estonia.

The annual increase the number of publications in dentistry from 1990 can be explained by the restoration of independence to the Baltic states and the establishment of academic centers that have provided training and research based on models from Western Europe countries and international research collaborations [19]. Currently, there are scientific collaborations between the Baltic and Scandinavian countries and of the Baltic countries, Russia continues to collaborate only with Latvia [20].

Data for this bibliometric study were obtained from two databases, the Web of Science and Scopus, for 1996–2018, as Scopus did not include citations before 1996 [21]. However, data from the past 22 was adequate for bibliometric analysis. Alternatively, the Google Scholar database could have been used, but this database has fewer bibliometric tools, generates multiple versions of the same publication, and can include non-research publications [22].

In this study, publications were retrieved that were not only in the dentistry category but also in the remaining biomedical...
categories that included keywords associated with dentistry. Current guidelines recommend multidisciplinary dental management not only for clinical cases but also for research studies [23]. Therefore, further analysis of scientific output in dentistry is required following the current broad search strategy, which was designed to compile an extensive database [4]. Therefore, dermatological and neuroscientific journals appeared in the list of publications, and of the three countries, publications by dental researchers in Lithuania were mainly published in dental journals.

This study had several limitations. Despite a large number of journals in the Scopus and Web of Science databases, there is bias in both databases between countries and language, with most publications being in the English language, which may introduce bias when performing comparative analysis. Also, the two databases were established in different years, with the Web of Science database established in 1995, and Scopus in 1996, and the databases had different journal indexing, which might have affected the results [24]. Also, the identification of the authors of the publications was affected by the variations in the names used for the authors, some of which were written using national letters, and the full first name or only the first letter was provided by the journals, resulting in difficulty in analyzing the data electronically [25]. To eliminate these errors, the searches for the authors were performed using the different forms of names included in the database or using the ORCID identifier [26].

There were also limitations in the analysis of the institutions where the studies were conducted. Most medical schools have university hospitals, and most authors were working as academics and clinicians [27]. Therefore, the same authors had different affiliations [28]. For example, the Hospital of the Lithuanian University of Health Sciences Kaunas Clinics was linked with the Lithuanian University of Health Sciences, the Tartu University Hospital was linked with the University of Tartu, and Pauls Stradins Clinical University Hospital and the Children’s Clinical University Hospital Riga were linked with Riga Stradins University. Therefore, it is recommended that authors of scientific publications include multiple institutional affiliations in the author information [29].

Conclusions

This study aimed to determine the number and quality of scientific publications in dentistry from the Baltic countries of Lithuania, Latvia, and Estonia between 1996 and 2018 using bibliometric analysis. During the past 22 years, authors from Lithuania had the most publications in the field of dentistry, and authors from Estonia had the most cited publications. The use of the h-index, g-index, and hgs-index identified the Lithuanian University of Health Sciences as being the academic center with the most cited publications in dentistry during the study period. Authors mainly published in native journals and collaborated with authors in Scandinavia and North America.

Conflict of interest

None.

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Conflict of interest

None.
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