The Main Infrastructure for Better Dental Implant Management: A Systematic Review on Dental Implant Registries

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Abstract
Background The importance of dental implant registry system has been well documented. However, no systematic review on the dental implant registry system can be found in the literature. Therefore, the aim of this study is to review the dental implant registry system to determine the goals, data elements, reports, data sources, capabilities and institutions that develop dental implant registry system.

Methods A systematic study was conducted in PubMed, Scopus, Web of Science and Embase databases. Also, samples of dental implant registry system were searched in Google and were included into the study. For evaluating the dental implant registry system, all English language studies were examined without time limitation. Non-English studies and papers such as conference abstracts were excluded.

Results The primary search identified 16905 articles. After eliminating duplicates, full texts of 53 retrieved articles were reviewed by the researchers and finally, 15 studies were included in this review. In this review, the goals of dental implant registry system were determined to be surveillance, complication management and etc. Also, the data elements of dental implant registry system were include patient information, implant information, etc.

Conclusion The results of this study provide dentists and other stakeholders with useful dataset on the development of dental implant registry system. It also provides a framework of the goals, characteristics, data elements and reports, data sources, and capabilities of dental implant registry system. The establishment of dental implant registry system will allow the control of complications of dental implants in the future. Systematic review registration CRD42019126424

Background
Dental implants are used to rebuild dentures [1, 2] and improve chewing performance, biomechanics and beauty [2, 3]. It also represents an alternative solution for patients who are dissatisfied with traditional methods or artificial teeth [4, 5]. Non-allergic dental implants are inserted in the jaw bones [6], as a way of establishing structural and functional connection between bones and the implant surface, which is called osseointegration [5]. It is estimated that about 18 million dental implants are
sold annually [7]. Improved dental implant properties have led to escalating demand for this material [8].

The material, shape, size and coating modifications have improved the clinical results of dental implants around the world. There are more than 1300 types of dental implants [5, 9]. High success rate, reduced risk of decay, sensitivity, and bone remodeling are among the benefits of dental implants [4]. However, dental implant also has a number of side effects such as "biological complications" which are functional disorders that induce adverse reactions in hard and soft tissues of implant prosthesis [10]. These biological complications are divided into two categories; mucositis and peri-implantitis [11-13]. Poor oral health, alcohol intake and smoking are some of the underlying factors that contribute to these complications [11, 14]. "Technical complications" refer to mechanical damages imposed on implant components [10, 15], which may lead to the loss of implants or increased number of implant repair sessions [10].

The technical and biological complications can be prevented through regular patient monitoring [10]. Due to the diversity of dental implant systems, identifying the system of dental implant in patients is a major challenge for dentists. Also, identifying the system, type of connection, and the implant length and diameter can be particularly time consuming. Therefore, it is necessary to store data related to implant properties on a database [16] and facilitate collaboration between a team of dentists [4, 17]. Some of the advantages of dental implant registry system include; active learning, improvement of standard care, guideline formulation, clinical research, greater patient participation, promotion of preventive measures, long-term evaluation, and improved quality of life in patients [7, 18]. A review of related studies and research websites reveals that no systematic review has ever been conducted on the dental implant registry system. The goal of present paper is to carry out a systematic review on the dental implant registry system to answer the following questions:

“What are the goals of a dental implant registry system?”

“What are the data elements of a dental implant registry system?”

“What are the reports of a dental implant registry system?”

“What are the data sources of a dental implant registry system?”
“What are the capabilities of a dental implant registry system?”

“What institutions have developed a dental implant registry system?”

**Materials And Methods**

This is a type of secondary study that reviews English language papers without any time limit. This study is registered on the PROSPERO[1] database (Registration No: CRD42019126424), and is based on PRISMA[2] guideline. Dental implant registries protocol available from:

http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42019126424. The studies that met the inclusion criteria set by the PICO[3] are listed in Table 1.

Table 1: PICO characteristics of study selection

| **Components**   | **Descriptions**                                                                                                                                                                                                 |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 Population     | Dental implants Research and research projects aimed at identifying goals, data elements, reports, data sources and developing institutions of dental implant registry systems. Examples of national, local, hospital-based and population-based registry systems worldwide. |
| 2 Intervention   | Dental implant registry system available through the digital library of Tehran University of Medical Sciences, PubMed, Scopus, Web Of Science and Embase databases and the research papers written in English (full text available) without any time limitation. Studies on the evaluation of dental implant registry system or its components (including dental systems, data elements, reports and outputs of the system, data sources, system capabilities). Exclusion criteria: Non-English studies, non-research papers such as conference abstracts and letters to the editor. Studies on clinical features of dental implants and their complications. Studies on new approaches to the treatment of dental implants and Randomized Clinical Trial. |
| 3 Comparison     | System goals System data elements System reports Data sources System functionality System developers |
| 4 Outcome        | Results of using a dental implant registry system |

In this study, the PubMed (MEDLINE), Scopus, Web of Science and Embase databases were searched up to Feb 2019 by two independent investigators. These databases were chosen as they contained studies in Computer Science and Medicines (medical informatics). Samples of registry systems at
national, local, hospital and demographic levels were searched in Google, trip databases and key journals, and related articles were reviewed by the authors to ensure the thorough coverage of the resources. The key journals included European Journal of Oral Implantology, Implant Dentistry, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Periodontics and Restorative Dentistry, International Journal of Prosthodontics, Journal of Clinical Periodontology, Journal of Dental Research, Journal of Dentistry, Journal of Oral Implantology, Journal of Craniofacial Surgery and Journal of Cranio-Maxillofacial Surgery.

After selection of articles based on entry criteria, they were subjected to meticulous analysis. The authors of papers that their full text was not available were contacted via email and they were added to the authorship if they replied. To determine the search strategy, keywords were investigated in MESH then five articles related to dental implant and 5 articles related to the registry system were extracted. Keywords were evaluated by a specialist medical librarian. Search strategy for PubMed database was as follow:

("Dental Implant*"[tiab] OR “tooth implant” [tiab] OR “implant dentistry” [tiab] OR “Dental Prostheses, Surgical” [tiab] OR “Surgical Dental Prostheses” [tiab] OR “Prostheses, Surgical Dental”[tiab]) AND (Registry[tiab] OR Register[tiab] OR Registration[tiab] OR registered[tiab] OR “Population Register”[tiab] OR “Health registers” [tiab] OR “registry system”[tiab] OR “Electronic registries”[tiab] OR “electronic disease registry”[tiab] OR “disease electronic management system” [tiab] OR “quality of care registries”[tiab] OR “Clinical quality registries”[tiab] OR surveillance[tiab] OR “registry-based surveillance”[tiab] OR “registry database”[tiab] OR “Computerized disease registry”[tiab] OR “Internet-based disease registry system”[tiab] OR “Computerized registry”[tiab] OR Monitoring[tiab] OR “Electronic monitoring”[tiab] OR (“data collection systems and registries”[tiab]) OR “medical data registry”[tiab] OR Database[tiab] OR Databank[tiab] OR “electronic databases”[tiab] OR “data repository”[tiab] OR “Recording systems” [tiab] OR “surveillance systems”[tiab]).

Endnote (X8, Thomson Reuters, NY) was used to identify articles with predefined criteria. Duplicate
articles identified in various database searches were removed. References and citations of articles selected for our review were analyzed and papers that met the PICO standards were included in the study. The retrieved articles were independently reviewed by two researchers RN and LS. At this stage, the title, summary and keywords of articles were reviewed by each researcher. If both researchers decided that the article was irrelevant, it was removed from the review process. In the absence of sufficient information at this stage to make a final decision, the article proceeded to the next stage. Also, in the cases where the two reviewers did not agree on an article, it proceeded to the next step for final decision based on the whole paper. At this step, the article was read fully to decide whether to keep it or remove it from the review. Thus, each article was read by two researches to make the final decision. If the two researchers had divergent views regarding the exclusion and inclusion of an article, they attempted to resolve the discrepancy through discussion; otherwise, a third party reviewed the article and made the final decision.

At this step, the information obtained from the included papers was categorized as a subject matter, then reported narratively and discussed at two meetings. This information covers the study objectives, including the system goals, data elements, system reports, sources of data, capabilities, and developer institutions of the dental implant registry system. Furthermore, tables were applied based on research questions.

[1] International database of prospectively registered systematic reviews in health and social care
[2] Preferred Reporting Items for Systematic Reviews and Meta-Analyses (healthcare)
[3] Population, Intervention, Comparison, Outcome(s)
[4] http://diglib.tums.ac.ir/

Results
In total, 16905 articles were identified in our initial search. After the elimination of duplicates, 14447 articles remained. Two researchers RN and LS removed 14394 articles after reviewing their title and abstracts, and finally the full texts of 53 articles were reviewed by the researchers for further assessment. Meanwhile, 11 papers that did not meet the inclusion criteria, 5 papers that were related
to Peri-implantitis, 8 papers that their full texts were not available and 14 papers that were clinical discussions were excluded. Finally, 15 studies were included in the systematic review (Figure 1).

Table 2 shows the main characteristics of dental implant registry systems obtained from the review of all 15 documents, which include system titles, data sources, capabilities, and developers of dental implant registry systems. Table 3 provides an exhaustive list of goals attributed to the dental implant registry system in six categories of surveillance, complication management, information management, improved quality of care, research and improved learning based on dental implant registries. Table 4 lists the data elements of dental implant registry systems in three categories of clinic information, patient information and implant information. Table 5 contains reports of the dental implant registry system in five categories of dental implant placement statistics, implants failure statistics, survival statistics, complications and other cases. Figure 2 shows the countries that have a dental implant registry system.

Discussion

This is the first systematic review to study dental implant registry systems and their goals, data elements, reports, data sources, capabilities and developers. This study can be seen as the first step in designing a dental implant registry system in the future. The following section illustrates the highlights of registry systems, especially the dental implant registry system.

Patient registry is a paper list or an electronic database that systematically collects uniform clinical data about specific groups of patients for a predetermined objective [35-37]. This type of registry is focused on a particular treatment or service [38]. Patient registry is a prospective observational database that describes natural history, epidemiology, disease burden over time and regional or national variations in treatment in addition to explaining the reason for failures of procedures, their side effects, and their cost-effectiveness, as well as effectiveness of interventions. Registries inform decision-makers about the quality and safety of devices and components [26, 35, 39].

A patient registry should be designed based on a purpose [36]. Krysinska et al stated that, the two factors of registry objective and investment are influenced by the design and scope of the registry [40]. The first step in designing a registry is to set realistic goals. In addition, a clearly defined
purpose helps to clarify the need for certain data. Clear and precise objectives also help to determine the structure, data collection process and data elements [36, 37]. Some registry goals may include improving patient care, comparing standards and monitoring device resistance [41]. The goals of a disease registry may include providing information to all stakeholders including doctors, policymakers, patients, insurance companies, research support, etc. [18]. A dental implant registry must have the required quality and achieve the predetermined goals [26]. Stey et al pointed out that one of the key elements in improving registry quality is obtaining reliable data elements [42]. Niederländer et al expressed that, faulty and non-precise structure and content of the disease registry system leads to heterogeneity of registries [26]. The diversity of goals and features of registries complicates their comparison. Standard data and information coordination allow data comparison across countries and regions [40]. The data elements of registries should be determined to facilitate scientific disciplines to achieve their objectives [36]. The minimum data elements of dental implant registry must include patient-related data, implant-related data, follow-up period (complications or use of antibiotics), early failure, patient support care (recorded at recall visits) and records of implant loss [18]. As mentioned earlier, data elements depend on the purpose of the registry and may cover a different range of information.

Krysinska et al stated that a successful and effective registry needs to design a workflow model with the lowest disruption, so that everyday aspect of medical activity can be integrated in the registry [40]. A good registry also must be able to integrate data from various sources. Data should have the following characteristics to integrate and link the registries; they should have a unique form and structure, and be available and timeliness [36]. Different types of data include cost, patient identifiers, disease/condition, treatment, laboratory, bio-samples, health care provider characteristics, hospital and insurance [36]. Data may be stored in the registry for its primary purposes. For example, the data sources of Swedish dental implant registry are electronic records that automatically transfer data from patient electronic records [7, 19, 20]. In Finland, data source is self-reported data obtained from dentists or collected by questionnaires for the long-term assessment of dental implants [21-23]. In Australia, data is directly obtained from patients, a dentist or dental laboratory (with the patient’s
Muir stated that standardization of reporting is essential to extract useful data [39]. Registries can be used for different types of information such as adverse events reporting, active surveillance of medical products, discovery of complications and risks, analysis of quality and stability of implants, prostheses safety, follow-up, monitoring, comparison of different registries, and publication of results [26]. In our study, the main reports are listed in five categories of dental implant placement statistics, implants failure statistics, survival statistics, complications, etc., as shown in Table 5.

Krysinska et al. stated that registry system should be user-friendly and support safe and secure data collection, data processing, data reporting, data linkage and automatic data capture [40]. A dental implant registry system needs to have recall and follow-up capability, management of biological complications [26] and recording in accordance with the implant maintenance and treatment protocols [25].

Institutions that support dental implant registry system development may include scientific associations, dental care stakeholders (dentists, national health agencies, insurance, etc.) and universities [18]. Also, for development of successful, effective and stable registries, multidisciplinary collaboration among key stakeholders including clinicians, medical researchers, policy makers and regulatory agencies, epidemiologists, statisticians, patients, healthcare systems, quality monitoring organizations, and health clinics is required [40, 43]. In our study, institutions that had developed dental implant registry system included Stockholm County Council in Sweden [7, 19, 20], The National Institute for Health and Welfare in Finland (THL) [21-23] and the Australian Information Commissioner [24]. In this regard, we suggest further collaboration between institutions to enhance the quality of dental implant registry system, data networks, and homogenous structure and content, which allows comparison across countries and regions and promotes oral and dental health.

**Strengths of research:**

This study represents the first attempt to review dental implant registries. The results of present study can be used to provide a suitable ground for the establishment of a dental implant registry system and to monitor and control complications of dental implants, which will lead to the
improvement of oral and dental health. The findings of this study can be employed by authorities, specialists and policy makers to prepare a favorable ground for the establishment of a dental implant registry system.

**Research Limitations:**

One major limitation of this study was the small number of papers about dental implant registry system. Therefore, we attempted to obtain our information from different sources like the results of research on dental implant registries rather than the registries themselves. The authors of articles that their full texts were not available were contacted via email to ask for the full-text articles. Another limitation was that our search was confined to papers published in English, and some registries may have been omitted for this reason. We did not perform a quality appraisal for the papers included in this study, because of the significant heterogeneity among the included studies. Papers included: annual reports, retrospective and prospective studies, website, and registry review. This heterogeneity of included papers restricted formal quality appraisal. However, to relieve information bias, they were extracted by two researchers and discussed at two consensus meetings.

**Conclusions**

The result of this study can help generate robust knowledge to provide transparent and accurate information to dentists, policy makers, patients, implant companies, ministry of health and other stakeholders about the development of dental implant registry system. It also provides a framework for the establishment of a dental implant registry system, control of complications of dental implants and promotion of oral and dental health.

**Abbreviations**

**BOP:** Bleeding On Probing  
**GIS:** Geographic Information System  
**N.A:** Not Available  
**PROSPERO:** International database of prospectively registered systematic reviews in health and social care  
**PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (healthcare)
Declarations

Ethics approval and consent to participate:

This research was approved by the Ethics Committee of school of Allied Medical Sciences of Tehran University of Medical Sciences (ethical code No.IR.TUMS. SPH.REC.1397.295).

Consent for publication:

Not applicable.

Availability of data and materials:

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests:

Author Roya Naemi, Hamid Reza Barikani, Leila Shahmoradi states that there are no competing interests.

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Authors' contributions:

RN participated in the search, conducted the review, articles independently reviewed, and drafting of the article. HRB participated in the drafting of the article, clinical management, third party review of articles and final decision and editing of the manuscript. LS participated in the concept/design,
articles independently reviewed, critical revision of article. All authors have read and approved the final manuscript.

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Figures
Figure 1: Screening process of articles included in this study
Figure 2: Dental Implant Registry Systems in Different Countries

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table 2 Characteristics of Dental Implant Registry Systems in Different Countries.docx
- Search strategy for each database.docx
- Table 4 Data elements of the dental implant registry system.docx
- Table 3 Goals of dental implant registry systems.docx
- Table 5 Reports of dental implant registry system.docx