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Dental implant quality registries and databases: A systematic review

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Abstract:

BACKGROUND: The importance of dental implant quality register has been well-documented. However, no systematic review conducted on dental implant quality register can be found in the literature. Therefore, the purpose of this study was to study the existed dental implant quality registries to explain the goals, data elements, and reports of dental implant quality registries.

MATERIALS AND METHODS: This systematic study was conducted in PubMed, Scopus, Web of Science, and Embase databases. For evaluating dental implant quality registers, all studies in the English language were examined with no time limitation. Case reports, conference abstracts, and letters to the editor were excluded. The analysis of the quality of the studies was done by the STrengthening the Reporting of OBservational studies in Epidemiology checklist.

RESULTS: The primary search identified 5565 articles. After eliminating duplicate articles and articles that did not meet the inclusion criteria and reviewing 40 full texts, 11 studies were included in this study. In this review, seven countries as Sweden, the USA, Canada, Germany, Finland, Australia, and South Korea had dental implant quality registers. Furthermore, the goals of dental implant quality registers were classified into the categories of research, epidemiology, administrative, clinical, and surveillance.

CONCLUSION: The results of this study provide dentists and other stakeholders useful information on the existed dental implant quality registers and databases worldwide. It also provides a framework of the goals, data elements, and reports of dental implant quality registry. The establishment of dental implant quality register will be beneficial for societies and also allows them to control the complications of dental implants in future.

Keywords:

Database management systems, dental implants, registries

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Introduction

Dental implants are used to rebuild dental prostheses[1,2] and improve chewing performance, biomechanics, and esthetics.[2,3] It is also represented as an alternative solution for the patients who are dissatisfied with traditional methods or artificial teeth.[4] Nonallergic dental implants are inserted in the jawbones,[5] as a way of establishing structural and functional connections between bones and the implant surface, which is called osseointegration.[4] It is estimated that about 18 million dental implants are annually sold.[6] Improved dental implant properties have led to an escalating demand for this material.[7] The material, shape, size, and coating modifications have improved the clinical results of dental implants worldwide. Furthermore, there are more than 1300 types of dental implants.[4,8] High success rate, the reduced risk of decay, sensitivity, and bone remodeling are among the benefits of dental implants.[9] However, dental implant has also a number of side effects like "biological complications," which are functional disorders inducing adverse reactions in the hard and soft tissues of implant prosthesis.[10] Accordingly, these biological complications are divided into two categories which are as follows: Mucositis and peri-implantitis.[10-12] Poor oral health,

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alcohol intake, and smoking are some of the underlying factors contributing to these complications.[10,13] "Technical complications" refer to mechanical damages imposed on implant components,[14,15] which may lead to the loss of the implants or the increased number of implant repair sessions.[14] The technical and biological complications can be prevented through regular patient monitoring.[14] Due to the diverse dental implant systems, identifying the system of dental implant in the patients is a major challenge for dentists. In addition, identifying the type of connection and the implant length and diameter can be particularly time consuming. Therefore, it is necessary to store the data on a database that are related to the implant properties[16] and also to facilitate collaboration among the members of a team of dentists.[9,17-19] Some of the advantages of dental implant quality register include the following: active learning, improvement of standard care, guideline formulation, clinical research, greater patient participation, promotion of preventive measures, long-term evaluation, and the improved quality of care for the patients.[6,20,21] Based on our knowledge, no systematic review has ever been conducted on the dental implant quality registers and databases. Therefore, the aim of this study is to review the dental implant quality registers and databases to determine the goals, data elements, and reports of dental implant quality registers and databases.

Materials and Methods

Study registration and protocol

This study was a type of secondary study and was registered on the international database of prospectively registered systematic reviews in health and social care (PROSPERO) and performed in terms of the preferred reporting items for systematic reviews and meta-analyses guideline.[22] Dental implant quality register protocol is available from http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID = CRD42019126424. Systematic review registration number was CRD42019126424.

Data sources and search strategies

In this study, the PubMed (MEDLINE), Scopus, Web of Science, and Embase databases were searched up to December 2019 by two independent investigators. These databases were chosen as they included the studies in Computer Science and Medicines (medical informatics). To determine the search strategy, keywords were investigated in MESH. Then, the search strategy was developed.

Data screening

Duplicate articles identified in various database searches were removed from endnote. The title and abstract of retrieved articles were separately reviewed by two researchers RN and LSh. If both the 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 the final decision, the article proceeded to the next stage. Furthermore, in the cases that the two reviewers had no agreement on an article, it proceeded to the next step for the final decision based on the whole paper. In this step, the article was fully read to decide whether to keep it or remove it from the review. Thus, each article was read by two researchers to make the final decision. If the two researchers had divergent views regarding the exclusion or inclusion of an article, they attempted to resolve the discrepancy through discussion; otherwise, a third party (HRB) reviewed the article and made the final decision. References of the articles selected for our review were analyzed using the forward/backward citation method and papers that matched the inclusion criteria were included in the study. The authors of those papers that their full texts were not available or there was insufficient information on their registry were contacted via E-mail and they were added to the authorship if they replied. For the articles that used a registry or database in several

Table 1: Inclusion and exclusion criteria

Criteria	Inclusion criteria	Exclusion criteria
Time	Without any time limitation	
Language	Journal articles written in English	Non-English studies
Electronic databases	Databases available through the digital library of Tehran University of Medical Sciences[3] in PubMed, Scopus, Web of Science, and Embase	
Subject	Dental implant quality registers or databases	Studies on clinical features of dental implants and their complications or new approaches of dental implants
Study design	Cohort study (retrospective, prospective, and longitudinal studies)	Review articles, systematic reviews, randomized clinical trial, case reports, conference abstracts, and letters to the editor
Dental implant quality registers and databases	Eelectronic registries or databases at national/local/regional/statewide level. Also, hospital/university clinics registries	Cross-sectional registry or databases
STROBE score	STROBE score above 11	STROBE score below 11

STROBE: STrengthening the Reporting of OBservational studies in Epidemiology

articles, the most important and relevant article was included in the study.

Data quality assessment

Strengthening the reporting of observational studies in epidemiology (STROBE) checklist was used to evaluate the types of observational studies.[23] This assessment was made by two researchers RN and LSh. Differences of opinion were resolved through discussion or consultation with a third party (HRB). Score 1 was given for all parts report and 0 scores for not providing one or more parts. Studies with a STROBE score below 11 were excluded from the study.

Data extraction

After the selection of the articles based on the inclusion criteria, they were subjected to meticulous analysis. In this step, the information obtained from the included papers was categorized as a subject matter, then it was reported narratively and discussed at two meetings. This information covers the study objectives, including determining the existed systems, goals, data elements, and reports of dental implant quality registers. Data extraction table was produced in Microsoft Excel, which include the authors name, journal, study design, STROBE score, country, year of establish, registry geographical coverage, data sources, objective(s) of the registry, number of the registered patients/implants, and data collection tool. In addition, separate tables were created for data elements and dental implant quality register reports. Furthermore, tables were applied based on the research questions.

Protocol amendments

Since key journals were indexed in PubMed (MEDLINE), Scopus, Web of Science, and Embase databases; they were not reviewed again. We skipped the Google Search and TRIP search engines due to the improved article quality and the reduced heterogeneity of findings. Hence, we decided to include only the articles that were related to the dental implant quality register. For a more comprehensive review, we performed a forward/backward citation review. In addition, we updated the inclusion and exclusion criteria to answer the study questions.

Results

Identified studies

In total, 5565 articles were identified. After the elimination of duplicates, 2189 articles remained. By means of two researchers, 2149 articles based on examining the title and abstract were excluded because they did not meet inclusion criteria [Table 1], and full texts of 40 articles were accurately reviewed. Ultimately, 11 studies were included in the systematic review [Figure 1]. The main features of dental implant quality registers and databases are presented in Table 2.

Description of studies

All the included articles were issued between 1993 and 2019. Of 11 articles included, six studies were retrospective (54.5%), two studies were prospective (18.2%), two studies were longitudinal (18.2%), and one study was retroprospective (9.1%). Five studies (45.5%) received 22 scores for STROBE. The results of the quality assessment with STROBE are given in Table 2. Distribution of studies by journal names and features are presented in Table 3. "Journal of dental research" has the first rank in impact factor (5.125). "The International journal of oral and maxillofacial implants" and "Clinical implant dentistry and related research" have the first rank in the number of studies.

Description of dental implant quality registers and databases

A survey of 11 studies revealed that the dental implant quality registers and database existed in 7 countries as follows: Sweden,[24] the USA,[25-29] Canada,[30] Germany,[31] Finland,[32] Australia,[33] and South Korea.[34] The oldest dental implant quality register was related to the Branemark Clinic, Public Dental Care, Region of Vastra Gotaland, Sweden[24] and the Tucson, Arizona, USA,[29]

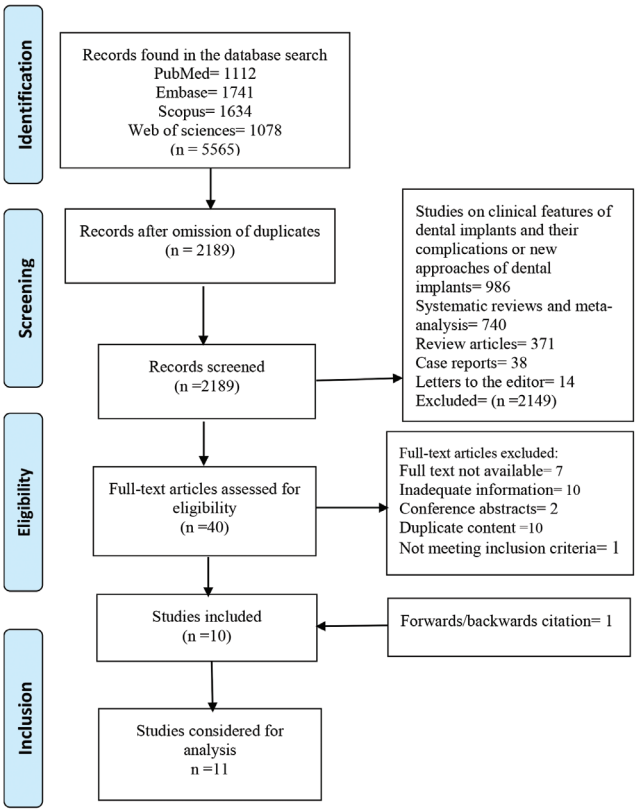

Figure 1: Flowchart of articles included in this study

Table 2: Main features of dental implant quality registers and databases

Authors/ year	Journal	Study design	STROBE score	Country	Year of establish	Registry geographical coverage	Registry leadership	Data sources	Objective (s) of the registry	Number of registered patients/implants	Data collection tool
Kordbacheh Changi *et al*. 2019[25]	Clinical oral implants research	Retrospective cohort study	21/22	USA	2011	University clinic	Columbia University College of Dental Medicine	Electronic oral health records	Epidemiology research	2127/6129	N.A[4]
Park *et al*. 2019[34]	Journal of clinical periodontology	Retrospective cohort study	22/22	Seoul, Korea	2008	University clinic	Yonsei university dental hospital	Electronic dental records	Clinical	N.A	N.A
Arlin 2002[30]	Implant dentistry	Prospective cohort study	21/22	Toronto, Ontario, Canada	1987	Private clinic	N.A	Electronic database	clinical	961/2774 (during 1987-2001)	Triton
Guo *et al*. 2015[33]	Australian dental journal	Retrospective cohort study	22/22	Melbourne, Victoria, Australia	N.A	Hospital clinic	Royal Dental Hospital of Melbourne	Electronic hospital database and patient records	Administrative epidemiology	-/1074 (during 2005-2009)	Titanium software, Spark Dental Technology
Weyant *et al*. 1993[26]	Journal of dental research	Longitudinal study	22/22	USA	1987	Department of Veterans Affairs	Veterans affairs medical center	Dental implant registry	Administrative research	598/2098 (based on selection criteria)	dBase III plus software
Carr *et al*. 2017[27]	The international journal of oral and maxillofacial implants	Retrospective cohort study	21/22	Rochester, Minnesota, USA	1997	Clinic	Mayo Clinic in Rochester, Minnesota	Medical records and electronic health records (since 1997)	Epidemiology clinical	6358/20600 (during 1983-2014)	N.A
Jemt 2018[24]	The international journal of prosthodontics	Retroprospective study	22/22	Region of Vastra Gotaland, Sweden	1986	Clinic	Branemark Clinic, Public Dental Care, Region of Vastra Gotaland, Sweden	Prospective logbooks	Epidemiology research	9343/41876 (during 1986-2015)	Special logbooks
Krebs *et al*. 2015[31]	Clinical implant dentistry and related research	Longitudinal study	22/22	Frankfurt, Germany	1991	University clinic	Department of Oral Surgery and Implantology of the Frankfurt University	Structured query language (SQL): impDAT and medical records	Surveillance	4206/12737 (during 1991-2011) for ANKYLOS implants	SQL database that converted to impDAT in 2008
Antalainen *et al*. 2013[32]	International Journal of oral and maxillofacial implants	Retrospective cohort study	20/22	Finland	1994	National	The National institute for health and welfare in finland (62)	N.A	Research	-/19538 (during 1994-2012)	Finnish Dental Implant Register
Starr *et al*. 2006[28]	Journal of oral implantology	Retrospective cohort study	17/22	USA	1998	University clinic	UFCD-J	UFCD-J administrative database	Surveillance	263/790 (during 1998 to 2005)	N.A
Becker *et al*. 2013[29]	Clinical implant dentistry and related research	Prospective cohort study	21/22	Tucson, Arizona, USA	1986	Private clinic	N.A	Triton system	Administrative	N.A	Triton based on microsoft access

STROBE: STrengthening the Reporting of OBservational studies in Epidemiology, UFCD-J: University of Florida College of Dentistry - Jacksonville Clinic

which were created in 1986. In addition, Columbia University College of Dental Medicine established a database in 2011.[25] Only the Finland registry was according to the national level, and the other countries were at the hospital/university clinic or on the other levels.[32,35] Branemark Clinic, Public Dental Care, Region of Vastra Gotaland, Sweden, registered 41,876 dental implants from 1986 to 2015[24] and Mayo Clinic in Rochester, Minnesota, USA, registered 20,600 dental implants from 1983 to 2014.[27] Based on the findings, dental implant quality registers had multiple goals. Moreover, four dental implant quality registers and databases had research (36%) and epidemiology (36%) purposes. Three of them had administrative (27%) and clinical (27%) goals and two of them had surveillance purposes (18%). As it was observed, both Tucson, Arizona, USA, and Toronto, Ontario, Canada, used Microsoft Access-based software (Triton). Department of Oral Surgery and Implantology of the Frankfurt, Germany, used a Structured Query Language-based database that was converted to impDAT in 2008. Table 4 lists the data elements of dental implant quality registers in four categories as sociodemographic, risk factors, dental implants, and follow-up and complications information that were extracted from the understudy dental implant quality registers and databases. As observed, age, sex, implant width/length, implant location, and data elements were present in all dental implant quality registers. Table 5 contains the reports of the dental implant quality registers in four categories of dental implant placement, dental implants failure, follow-up, and complications.

Discussion

This was the first systematic review aimed to study dental implant quality registers and databases. According to our standard strategy, 11 studies were included in our study. Based on the results of the study, dental implant quality registers were recognized with various levels of geographical coverage. Finland had dental implant quality register at the national level,[32] and Sweden, the USA, Canada, Germany, Australia, and South Korea had dental implant quality register at university,[25,28,31,34] hospital,[33] clinic,[24,27,29,30] or department[26] levels that systematically collected data about dental implants. Factors such as funds, obligatory or voluntary cooperation, the purpose of the registry, and level of maturity can affect the

Table 3: Distribution of studies by journal names and features

Journal name	Impact factor	Quartile	Count (%)
Clinical oral implants research	3.825	Q 1	1 (9)
Journal of clinical periodontology	4.164	Q 1	1 (9)
Implant dentistry	1.214	Q 2	1 (9)
Australian dental journal	1.282	Q 2	1 (9)
Journal of dental research	5.125	Q 1	1 (9)
The international journal of oral and maxillofacial implants	1.734	Q 2	2 (18)
The international journal of prosthodontics	1.533	Q 2	1 (9)
Clinical implant dentistry and related research	3.212	Q 1	2 (18)
Journal of oral implantology	1.062	Q 3	1 (9)
Total=9 Journal			11 (100)

Table 4: Data elements of dental implant quality registers and databases

Socio-demographic category		Risk factors category		Dental implants category		Follow-up and complicationscategory	
Data elements	(%)	Data elements	(%)	Data elements	(%)	Data elements	(%)
Age	100	Diabetes mellitus	45	Implant width/length (mm)	100	Time of follow-up from surgical placement	91
Sex	100	Heart disease	45	Implant location	100	Time of Implant failure	73
Ethnicity	18	History of periodontitis	18	Implant system	82	Implant mobility	18
Race	9	Osteoporosis	36	Number of implant placement pre patient	45	Bone loss	36
Smoking status	64	HIV infection	18	Time of implant placement	82	Ill-fitting/poorly designed prosthesis	27
Bone volume, bone quality	36	Bruxism	9	Affiliation of surgeon	55	Wound dehiscence	18
		Autoimmune conditions	9	Surgical procedure	45	Pain	36
		Inflammatory condition	9	Immediate or delayed implant placement	55	Swelling	27
		Neuropsychiatric condition	9	Time of prosthesis placement	45	Hemorrhage	27
		Chemo and radiation therapy	27	Type of implant-supported prosthesis	45	Infection	45
		Postmenopausal status	9	Bone graft materials	55	Peri-implantitis	9
						Sinus membrane perforation	27

Table 5: Reports of dental implant quality registry

Category	Reports
Dental implant placement	Total implants placed, implant types, total number of operations and implants placement operations annually, implant placement by age group and sex, Implants placement by site (maxilla or mandible) and year, length of the inserted implant (maxilla or mandible) in millimeter, number of patients treated with fixed/removable replacements, implantation method, and implant supportive technique
Dental implant failure	Total removed implants, implants removed from the maxilla or mandible by tooth, total number of early and late implant loss, length of the removed implant (maxilla or mandible) in millimeter, time between implant placement and its removal, and factors affecting the probability of implant loss
Follow-up	Follow-up duration for overall survival, overall survival, survival by sex, and number of successful implant by implant type
Complication	Complication rates, prosthesis/biologic complications

geographical coverage of the registry.[36,37] The use of registries with limited coverage to estimate the prevalence, incidence, and performed activities is limited,[37] but when these registers are used to assess performance, quality can be of critical value and interest to researchers.

Department of Oral Surgery and Implantology of the Frankfurt University, Germany, registered 12,737 dental implants from 1991 to 2011[31] and the National Institute for Health and Welfare in Finland (THL) registered 19,538 dental implants from 1994 to 2012.[32] The number of implants registered in the Yonsei University, Seoul, Korea and Tucson, Arizona, USA were not mentioned here, since the few/none of the registers put their register in the perspective of the total number of implants placed in the respective country, which prevented further investigation and comparison in this study. On the other hand, meta-analysis was not appropriate due to the heterogeneity of registry data and implant systems.

The first step in designing a registry is to set realistic goals, and a dental implant quality registry must have predetermined goals. Dental implant quality register's goals for data collection can be classified as follows: (1) surveillance: Showing long-term outcomes of different brands and types of implants; (2) epidemiology: Presentation of dental implant statistics and evaluation of the incidences of complications such as peri-implantitis; (3) research: Discovering the risks factors for implant failure and participating in multicenter studies; (4) administrative: Comparing the survival and success rates of implants and evaluation of the survival times; and (5) clinical: Tracking the survival of dental implants in the patients with specific conditions (Down syndrome, diabetics, smokers, etc.) and evaluation of implant systems. A registry or database should be designed based on a purpose.[38] Accordingly, Krysinska *et al*. stated that the registry objective affects the design and scope of the registry.[37] In addition, clear and precise objectives also help to determine the structure, data collection process, and required data elements,[38,39] and prevent unnecessary data collection.[35]

In this study, data elements of dental implant quality registers and databases were classified into patient-related (sociodemographic and risk factors), implant-related, and follow-up data. As mentioned earlier, data elements depend on the purpose of the registry different ranges of data and information. Stey *et al*. pointed out that one of the key elements in improving the registry quality is obtaining reliable data elements.[40] The data elements of registries should be also determined to facilitate the scientific disciplines for achieving their objectives.[38] The diversity of goals and features of registries complicates their comparison. Nonprecise structure and content of the disease registry system lead to heterogeneity of registries.[41] Standard and integrate data elements allow data comparison and data sharing across the countries and regions.[37] Serious concerns regarding the privacy and confidentiality of patients' information have led to the development of data protection regulation (for example, Data Protection Directive (95/46/EC), European Surveillance System [TESSy], General Data Protection Regulation, and Health Insurance Portability and Accountability Act) in different countries, which are not always the same.[38,42] These regulations may effect on the selection of data elements, the use of data, and the distribution of information.[42] In some registries, legal requirements become more specific depending on the purpose and nature of the data to provide a security framework to maintain the privacy and confidentiality of individuals to collect, process, share, and publish health care information.[38,43,44]

The countries under study used Triton, Titanium, dBase III Plus, logbooks, and impDAT software. In recent years, data collection has been promoted by information technology.[45] Web-based registry facilitates the collection of accurate and complete data; reduces the costs; and makes it easy to use, share, and interact data.[6,46,47] Registry system should be user-friendly and support the safe and secure data collection, data processing, data reporting, data linkage, and automatic data capture.[37] Today, many national and regional quality registers in the medical field increasingly used web-based questionnaires named patient-reported outcome measures (PROMs) to obtain a perception of patients' opinions on the outcomes of treatment or procedure.[6,48,49] PROM facilitates the reporting of patients' health status/quality of life and functional ability before and after treatment.[6,48] In future, PROMs can be added to the dental implant quality registers for

improve clinical outcomes of dental implants, quality assurance, clinical monitoring, national benchmarking, and comparative effectiveness research.[49,50]

Reporting the incidence of dental implants and its complication is a challenge because of small sample size, short-term follow-up, patient selection, various study designs, and available resources.[6,12,51-54] In this study, the main reports of dental implant quality registers are classified into four categories as dental implant placement, implants failure, follow-up, and complications. Muir stated that standardization of reporting is essential to extract useful data.[55] Dental implant quality registers by rendering the high-quality, valid, and reliable data are powerful tools for planning, benchmarking clinical outcome nationally and internationally, active surveillance of medical products, discovery of complications and risks, analysis of quality and stability of dental implants, and monitoring of the patients.[41,56-61] This will ultimately improve the patient care and safety. Despite these multiple gains of dental implant quality registers and databases, many countries have overlooked having a dental implant quality registry. The results of the present study can be used to provide a suitable ground for the establishment of a dental implant quality registers for monitoring and control the complications of dental implants and also to improve dental health. This study represents the first attempt to review dental implant quality registers and has been recorded in the PROSPERO database. In fact, it is an added value for systematic review articles, and by registering a protocol in this system, it prevents duplicate systematic review studies and helps in conducting effective studies. A comprehensive review of the databases was performed under the supervision of a medical librarian and information science. We performed a quality assessment for the papers included in this study via the STROBE checklist by two researchers. Based on STROBE, the quality of the included papers was obtained good. One major limitation of this study was the small number of papers on dental implant quality registers. The authors of articles that their full texts were not available or were insufficient were contacted via e-mail to ask for their full-text articles. In addition, another limitation was that our search was confined only to the papers published in English, and some registries may have been omitted for this reason. The lack of dental implant quality registries and databases makes clinical research, evaluation of treatment outcomes, and quality control of care a challenge. Therefore, it is necessary to establish a dental implant quality registry and database for clinical research, evaluation of treatment results, monitoring the quality of clinical care, patient follow-up, monitoring the performance of health-care providers, maintaining health-care at the desired level, increasing patient safety, and strategic planning.

Conclusion

The results of this study provide a framework for the establishment of a dental implant quality registry to dentists, policymakers, implant companies, ministry of health, and other stakeholders. It is better for the leading countries in this field to share their experiences with other countries. Furthermore, we suggest establishing a Minimum Data Set of dental implants to facilitate national and international studies.

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Conflicts of interest

There are no conflicts of interest.

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