Malocclusion indices and their applications in public health: a review study
Índices de oclusopatia y sus aplicaciones en salud pública: un estudio de revisión

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Abstract
Health indices are important to measurement of the presence and severity of diseases. The objective of this study was to perform a literature review about malocclusion indices and analyze their applications in the public health field. The research was performed by consulting Pubmed, SciELO, Web of Science, Scopus, Bireme and Embase databases, using the following terms: public health, epidemiological methods, indices, epidemiological surveys, preventive dentistry, malocclusion, and orthodontics. Publications on the development and use of malocclusion indices in clinical and epidemiological studies were included, without restrictions of methodology and language. Fifty-two indices and their variations were identified. Of these, most were intended for individual assessments and their use in public health was difficult due to the requirements for their application, including the need for specialists, plaster models analysis, complementary exams such as cephalometric radiographs and photographs, specific equipment, the need for longitudinal monitoring of cases, and exclusively objective or subjective assessments. Some malocclusion indices present positive aspects and partially evaluate physical, functional, psychological, and social conditions. However, it is still challenging to find a unanimous index that fulfills the requirements for assessing the severity, treatment need, and impact of malocclusions on the individual’s quality of life with applicability in public health.

Descriptors: Malocclusion; Public Health; Epidemiologic Methods; Health Surveys.

INTRODUCTION
Action planning, strategy development, and public health decision-making must be supported by accurate and reliable epidemiological data. Therefore, health indices are of fundamental importance since they allow the measurement of the presence and severity of diseases and provide information for the development and efficient application of public health policies.

Malocclusion is the third major oral health problem, which may affect self-esteem due to aesthetic, speech, functional, and psychosocial changes, impairing the individual’s quality of life. Thus, it is necessary to develop appropriate indices for the analysis of malocclusions in population studies, highlighting...
their functionality in determining the need and priority for treatment besides detecting objective signs and providing information that allows a careful social analysis and enables the rational allocation of human, material, and financial resources for orthodontic therapy in public health.

Epidemiological studies show that the prevalence of malocclusions can vary from 62% to 95.73% between 6 and 9 years of age, and despite these significant values, malocclusions remain unresolved in most cases5,9. The denomination of malocclusions involves dental, facial, and skeletal abnormalities of varying degrees and severity, but the differences among them are not always easily defined. Despite these significant values, malocclusions remain unresolved in most cases. The denomination of malocclusions involves dental, facial, and skeletal abnormalities of varying degrees and severity, but the differences among them are not always easily defined. Malocclusion is a complex challenge to develop and standardize applicable malocclusion indices in public health.

Several malocclusion indices have been proposed over time using different evaluation criteria, but the utility for individual diagnosis and epidemiological studies must be analyzed. Moreover, the lack of standardization of a malocclusion index limits the comparison between studies and causes difficulties in the development of actions aimed at defining the need for treatment in the public health context. Therefore, this study conducted a literature review on malocclusion indices and developed a critical analysis of their applications in public health in the world.

**MATERIAL AND METHOD**

This review study included works published in the Pubmed, SciELO, Web of Science, Scopus, Bireme, and Embase databases. The databases search considered the period from 1899 to 2019 and used the following descriptors: public health, epidemiological methods, indices, epidemiological surveys, preventive dentistry, malocclusion, and orthodontics. Publications on the development and use of malocclusion indices in clinical and epidemiological studies were included, without restrictions of methodology and language. The titles and abstracts of the articles found were evaluated, and the eligible versions were obtained for full reading and analysis.

**RESULTS AND DISCUSSION**

Through the complete reading of the selected articles, 52 indices and their variations were identified for the evaluation of malocclusions. Table 1 presents the main characteristics of the identified indices.

| Author(s) | Description |
|---|---|
| **Angle Classification** | The index classified the malocclusions according to the following: Angle’s class I, with the mandibular first molar inysocclusion; Angle’s class II, with the mandibular first molar inysocclusion; Angle’s class III, with the mandibular first molar inysocclusion. |
| **Lischer Classification** | The index classified dental positioning as Class I, Class II, Class III, and Class IV. |
| **Stanton Model Analysis** | The index evaluated the malocclusions in plaster models using Stanton’s pantograph. |
| **Prevalence and Incidence Index** | Based on the classification of the malocclusions, the index evaluated the presence of malocclusions in public health. |
| **Cephalometric Analysis** | A quantitative method for evaluating malocclusions using cephalometric radiographs, and linear and angular measurements on teeth and skull. |
| **Facial Orтомetric Analysis** | The index determined the presence of malocclusion using the facial orthometric, indicating deformations, and directing the specific points on the face, to perform measurements and quantify the malocclusion. |
| **Occlusion Feature Index (OFI)** | The National Institute of Dental Research classified the malocclusions as very small, small, moderate, or severe, considering the presence of crowding, interincisal angle deviation, dental projection, and deep or open bite. It correlated the presence of malocclusions with the development of periodontal diseases. |
| **Malalignment Index** | The index used a customized plastic ruler to measure changes in dental positions, assigning scores to the measurement results, and assessing the severity of the malocclusions, thus leading to epidemiological surveys and address the need for orthodontic treatment. |
| **Handedness Index** | The index classified the malocclusions according to the severity into mild, disabling, or disfiguring. |
| **Dentofacial Anomaly Set** | The index defined the set of Dentofacial Anomalies to standardize the nomenclature of malocclusions. |
| **Björk Index** | The index determined the presence of malocclusions using a metal instrument appropriate for measurement, evaluating dental projection, open bite, lateral, midline, and distance. It estimated the type, duration, and time to start treatment. |
| **Treatment Priority Index (TPI)** | The index determined the need for orthodontic treatment prioritizing considering the following factors: teeth out of position, crowding, deep bite, dental projection, mandibular protrusion, and open bite. |
| **Eastman Esthetic Index (EEI)** | The index diagnosed the presence of malocclusions and treatment priority by applying a questionnaire on personal satisfaction regarding dental appearance and assessing oral and dental features such as deep bite, dental projection, open bite, lip-lingual deviation, gum recession, and the severity of mandibular asymmetries, and fracture in anterior teeth. |
| **Fisher & Adkin Index** | The index evaluated the presence of malocclusions and treatment priority using plaster models identifying a specific cluster of dental characteristics. |
| **Oral Health Surveys: Basic methods, 1st edition** | The index was published in the first edition of Oral Health Surveys: Basic methods, providing clear information on malocclusions and advising on the need for orthodontic treatment. |
| **Occlusal Index (OI)** | The index determined the presence of malocclusions by evaluating dental development, molar relationship, dental projection, deep bite, crowding, displacement, midline changes, and absence of permanent teeth. It classified them as good, small deviations without treatment need, small deviations with small treatment needs, and larger deviations with more complex treatment needs. |
Table 1 (Continuation). Malocclusion indices according to the author, year of development and description.

| Index | Author(s) | Description |
|-------|-----------|-------------|
| The Six Normal Occlusion Keys | Andrews (1973)* | The index determined the presence of malocclusions through molar relationships, tooth angulations, incisal inclinations, tooth rotations, tooth contacts, and the line angles. |
| Baume Index | Baume et al. (1973)* | The index was composed of 3 categories: dental measurement (agreement, superimposed teeth, uncorrected tooth positions), extra-arch (crowding, spacing, anterior irregularities, vectorial analysis), and arch (molar relationship, posterior open bite, posterior cusp involvement, dental projection, deep bite or open bite, midline deviation, affected soft tissue). |
| Uniform Method for Measuring Orthodontic Treatments | WHO (1973)*; Fuchs (1973)* | The index aimed to develop a system to measure malocclusions with minimal applications and results that could be compared. It examined the permanent dentition through dental, intra-arch, and inter-arch examinations. |
| Index Swedish Medical Board (ISMBH) | Lindner-Aronson (1973)* | The index determined the need for orthodontic treatment with priority for disabled cases. Composed of 4 grids. Grid 4 treatment required dismissing features (defit lip or palate, retained upper incisors and extensive aplasia), Grids 3 and 2 involved elective treatment (deep bite with gingival irritation, crosstube transverse, canines retained, dental rotations with aesthetics and functional impairment, incisors inclinations with aesthetic and/or functional impairment, deep bite, crowding or spacing, infra-occlusion and moderate rotations), and Grid 1 involved the presence of malocclusions. |
| Ingersoll & Sommerman Index | Ingersoll & Sommerman (1973)* | The index determined the presence of malocclusions and treatment priority based on abnormal dental position and size, space disorders, and functional impairment, space disorders involving the muscular system, and disorders of the occlusal system. |
| Little's Irregularity Index | Little (1975)* | The index evaluated the need for treatment according to the severity of the malocclusions using a palatometer in a plastic splint to measure the dental crossbite, classified them as perfect, mild, moderate, severe, or very severe alignments. |
| Gottlieb Index | Gottlieb (1975)* | The index evaluated the outcome of orthodontic treatment observations of various characteristies such as relationship, canine relationship, interception, open or deep bite, dental projection, molar, rotations, crowding or spacing, arch shape, torque, and dental parallelism. |
| Kowlowski & Prabhul- Anderson Index | Kowlowski & Prabhul-Anderson (1975)* | The index determined treatment priority based on clinical criteria such as dental projection, deep or open bite, upper intermolar distance, joint-gonio angle, lower arch length, and angle resulting from the difference in maxillary and mandibular sizes. |
| Oral Health Surveys: Basic methods, 4th ed. | WHO (1977)* | The index recognized that there was no consensus for a Malocclusion Index, and recommended that it should be developed to contain all information concerning economic, and social factors. |
| Eismann Index | Eismann (1980)* | The index evaluated the effectiveness of orthodontic treatment by observing before, in the end, and after the installation of the retainer. It observed factors that produced malocclusions such as crowding, spacing, anterior open bite, posterior open bite, crowding, dental projection, deep bite, midline transverse changes, incisor rotations, axial inclinations, canine eruption, and interproximal relationships. |
| Berg & Freundland Classification | Berg & Freundland (1980)* | The index evaluated the clinical photographs with a classification ranging from “very attractive” to “least attractive”. The classification should be judged by the individual, and individuals in need of orthodontic treatment. Developed with the purpose of determining facial attractiveness for reference for the need for orthodontic treatment. |
| Dental Facial Attractiveness (DFA) | Todesco et al. (1980)* | The index determined the presence of malocclusions, the severity and need for orthodontic treatment by examining dental photographs, crowding in the incisor region, spacing in the incisor region, diastemas, anterior maxillary yawning, anterior mandible misalignment, anterior maxillary projection, anterior open bite, and molar relationship. The changes were assigned different weights resulting in a score that determined the severity and, consequently, the need for treatment. |
| Dental Aesthetic Index (DAI) | Cans et al. (1988)* | It was recommended the Malocclusion Index to diagnose malocclusions in 5-6 year-old children according to conditions: normal, no occlusal changes; 1) with occlusal changes and without loss of regular alignment, moderate/severe, unacceptable defect in facial appearance, or impossible chewing functioning, problem due to malocclusion of 9 mm or more, anterior cusp involvement greater than or equal to one tooth, open bite, midline altered by 4 mm or more, crowding or spacing of 9 mm or more, and no information on possible evaluation, or when age is inappropriate. |
| Oral Health Surveys: Basic methods. 3rd ed. | Wang et al. (1987)* | The index determined the evaluated the plan of the malocclusions using different models to evaluate the dental projection, open or deep bite. The index determined all dental, distal, inter-incisive angles, inter-ocular angles, occlusal planes, vertical relationship, occlusal surfaces, surface characteristics, and discrepancies. |
| Richmond Classification | Richmond (1987)* | The index evaluated the intensity and oriented the treatment plan of the malocclusions using different models to evaluate the dental projection, open or deep bite, diastemas, distal, inter-incisive angles, inter-ocular angles, occlusal planes, vertical relationship, occlusal surfaces, surface characteristics, and discrepancies. |
| Standardized Continuum of Aesthetic Need (SCAN) | Evans & Shaw (1987)* | The index determined orthodontic treatment priority using a factorial scaling model with 4 levels or 5 sublevels and visual comparison with various different positions. The images were evaluated by dental surgeons, parents, and young affected by malocclusions. |

Table 1 (Continuation). Malocclusion indices according to the author, year of development and description.

| Index | Author(s) | Description |
|-------|-----------|-------------|
| Index of Orthodontic Trajectory (DIT) | Brook & Shaw (1980)* | The index diagnosed the presence of malocclusions and the need for orthodontic treatment using the Dental Trajectory Component (DTC) and the Aesthetic Component (AC). This index was used to establish a customized system for orthodontic treatment. |
| Peer Assessment Rating (PAR) | Richmond et al. (1990)* | The index evaluated the orthodontic treatment plan on plastic models before and after orthodontic treatment with the use of a customized ruler. The index offered uniformity and standardization in the evaluation of orthodontic treatment results. |
| Malocclusion Index - Supplement | Brazilian Ministry of Health (2001)* | The index suggested changes in the Malocclusion Index, adding to category 1 (mild), information of dental changes, such as uni or bilateral cleft lip or cleft palate, deep bite, or dental projection above 2 mm. |
| Oral Health Surveys: Basic methods, 4th ed. | WHO (1997)* | The index determined treatment results using the occlusal radiographic exams and through orthodontic treatment, concluding that there were no consensus for the use of new indices. It evaluated lateral eruption, crowding, pronounced dental projection of 4 mm or more, posterior influence of deciduous molars, palatal palpation of canines, presence of third molars, deep bite, and open mandibular size. |
| Objective Grading System | American Board of Orthodontics (1998)* | The index determined the presence of malocclusions at 9 and 14 years of age, by non-specialist professionals and with rapid implementation. It evaluated lateral eruption, crowding, pronounced dental projection of 4 mm or more, posterior influence of deciduous molars, palatal palpation of canines, presence of third molars, deep bite, and open mandibular size. |
| Insogus- Håhlstrom & Hagberg Index | Insogus, Håhlstrom, & Hagberg (1994)* | The index determined the need for treatment in children by evaluating dental projection, deep or open bite, and first molar relationships, and first molar rotation and the need for treatment with a grade of 1 (severe need), 2 (high need), 3 (moderate need), 4 (no need). |
| PeerAssessment Rating (PAR) | PeerAssessment Rating (PAR) (1995)* | The index determined the need for orthodontic treatment for patients with severe crowding. The index indicated that the guidelines of previous studies, evaluating characteristics such as dental projection above 0.5 mm, anterior crossbite, deep accentuated bite, and bone tissue destruction, were not enough to identify the variation of the HD index. |
| Malocclusion Index to Children | Aon (2014)* | The index evaluated the need for orthodontic treatment in children, including canines. It employed methodologies similar to the HD index, consisting of 4 groups: 1) very great risk, 2) great risk, 3) medium risk, and 4) low risk. |
| Handappraising Labio-lingual Deviations- California Modification (HLD - Calif) | Parker (1997)* | The index determined the need for orthodontic treatment by assigning scores to the individual, evaluating examinations of the individual with malocclusions, evaluating characteristics such as dental projection above 0.5 mm, anterior crossbite, deep accentuated bite, and bone tissue destruction, were not enough to identify the variation of the HD index. |
| Handappraising Labio-lingual Deviations- California Modification (HLD - Calif) | Enz et al. (2004)* | The index determined the need for orthodontic treatment by assigning scores to the individual, evaluating examinations of the individual with malocclusions, evaluating characteristics such as dental projection above 0.5 mm, anterior crossbite, deep accentuated bite, and bone tissue destruction, were not enough to identify the variation of the HD index. |
| Incisal Proximity Outcome and Need (IPO) | Daniel & Richmond (2000)* | The index determined the need for treatment using the Incisal Proximity Outcome and Need (IPO) and the HLD variables. The HDL M4 considered class II severe, anterior tongue, and posterior tongue involvement, anterior incisor crowding, and unilateral posterior crowding. Reduced HLD need for treatment to scores 2 mm for dental projection and 1 mm for a greater angle, and scores 3 and 4, respectively. |
| Treatment Difficulty Index (TDI) | Pitt et al. (2006)* | The index determined the difficulty of planning and pursuing orthodontic treatment, including canines. It employed methodologies similar to the PAR index, using plastic models and radiographs before orthodontic treatment. It evaluated treatment time, rectangular arch use, and treatment duration. |
| Baby Risk of Malocclusion Index (Baby ROMA) | Griepenkov et al. (2019)* | The index identified malocclusions in 5-year-old children. Determined early, during the first year of life, it identified risks for installation or worsening of the malocclusion at high, medium, and low risk levels. Based on the IOM risk index, it formulated four grades: systemic, craniofacial, dental, and functional. Regarding scores from 1 to 3, 3 to 5, and 5 to 7, respectively, a score ≥ 7 indicated possible worsening of the problem requiring follow-up treatment; a score 1 to 3 indicated possible worsening of the problem requiring follow-up treatment; a score ≤ 4 indicated no need for treatment. |
Several indices have been developed over the years to evaluate malocclusions considering different aspects in their development, including identification, classification, and severity, need, applicability, and priority of treatment, functional changes, psychosocial disorders, and evaluation of orthodontic treatment efficiency and solubility. Most of the indices were appropriate for individual evaluations; however, their use in public health was difficult due to certain applicability conditions, including the need for specialists, plaster models, complementary exams such as cephalometric radiographs, photographs, specific equipment, and the need for longitudinal monitoring besides requiring exclusive objective or subjective evaluations. Thus, in the context of public health, the importance of assessing the need and priority for the treatment of individuals is highlighted, as well as obtaining information to adequately allocate the necessary resources to meet the population demand and avoid social inequities2,64,65.

Angle’s classification was one of the first indices elaborated in 1899 by Angle, the “father of modern orthodontics”, who elected Apollo de Belvedere’s face as normal11. However, this classification determined the presence of sagittal malocclusions, omitting data related to transverse and vertical discrepancies11,66. With the recession of 1929 and the advent of the First and Second World Wars, public health issues increased due to the global situation of social collapse. This contributed to the search for indices that could determine the need for orthodontic treatment in public health because, until then, the specialty was considered accessible only to wealthy individuals67,68.

It should be noted that malocclusion indices can be used from an individual perspective comprising objective factors or a public health perspective considering population groups, defining malocclusions as a dental and skeletal change that can cause a social disadvantage. In this sense, for decades the World Health Organization (WHO) has been making recommendations for the problem to reach the public spheres coherently3,27,38,52,62. In 1962, the WHO proposed the structuring of standardized methods for the study of oral diseases, naming malocclusions as a “Set of Dentofacial Anomalies”21. In 1971, the first edition of the Oral Health Surveys: Basic methods was published, providing guidance on the need for orthodontic treatment27. Aiming at broad application and reproducibility, the WHO and the World Dental Federation developed the Uniform Method for Measuring Occlusal Traits; however, this method did not evaluate psychosocial factors in individuals affected by malocclusions31,32,69.

The second edition of Oral Health Surveys: Basic methods described a lack of consensus on an index for malocclusions and suggested that the measurement of these dysfunctions should consider health, economic, and social factors30. In its third edition, the Oral Health Surveys: Basic methods presented the Malocclusion Index to diagnose and measure malocclusions in 5-year-old children3,9,70. The Oral Health Surveys: Basic method in its fourth edition suggested the Dental Aesthetic Index (DAI) to be considered as the standard for the epidemiological survey of malocclusions62. In the 5th edition, the Oral Health Surveys: Basic methods did not recommend a new index for malocclusions and suggested following the general guidelines of the previous editions62.

Such efforts reflect the difficulty and need to institute an adequate and standardized index for the evaluation of malocclusions in epidemiological studies. Several indices such as the Stanton Model Analysis, Hellman’s Anthropometric Index, and Moore’s Clinical Needs Index were useful in evaluating individual malocclusions, but the need for specific equipment, complementary tests, and specialists made it difficult to apply them in studies with larger samples13-15. Similarly, Dows developed an evaluation method based on cephalometric radiographs, with adequate results for individual diagnosis17; however, it was expensive, time consuming, and complex for use in epidemiological surveys. Elsasser clinically evaluated malocclusions using a facial orthometer and although it could be used by non-specialists, this method presented a functional gap because it did not define treatment priorities16.

An important issue related to the development of malocclusion indices is the restricted approach of objective clinical information, such as dental and occlusal characteristics, disregarding the psychosocial aspect which may restrict its application in public health, as observed in the Index of Prevalence and Incidence, Occlusion Feature Index (OFI), Six Keys of Normal Occlusion, Kowalski and Prahl-Andersen Index, Richmond Index, and Kirschen Index16,19,26,37,43,55.

To relate the severity of malocclusions with the need for treatment, several indices such as Handicapping Labio-lingual Deviations (HLD), Occlusal Index (OI), Malalignment Index, Treatment Priority Index (TPI), Index Swedish
Medical Health Board (ISMHB), Little Irregularity Index, and Handicapped Labio-Lingual Deviation index with California modifications (HLD CalMod), were developed based on exclusively clinical and objective criteria for indicating and clarifying the need for orthodontic intervention\textsuperscript{2,20,23,28,33,35,57}. However, they presented gaps in public health applications because they did not consider the individual’s social context.

Facial morphology was used as a basis for evaluating malocclusions, as proposed in the Ingervall and Ronnerman index and the Facial Pattern analysis; considering the physiognomy to determine the presence of the pathology, with little applicability in epidemiological surveys.\textsuperscript{34,60} Other indices exclusively analyzed the presence and need for treatment of malocclusions, thereby limiting their use in public health, such as the Standardized Continuum of Aesthetic Need (SCAN), and the Peerlings index, which were based on evaluations of extraoral photographs, highlighting the relationship of treatment with the search for improved aesthetics and self-esteem.\textsuperscript{44,50}

Some indices considered the importance of both objective and subjective characteristics. The Eastman Esthetic Index (EEI) analyzed dental characteristics and applied a questionnaire on personal satisfaction\textsuperscript{24}. The Freer and Adkins index ensured that the individual was not excluded from treatment based only on clinical criteria\textsuperscript{25}. The Handicapping Malocclusion Assessment Record (HAMAR), Baume index, and the Dental Facial Attractiveness (DFA) considered the effects caused by malocclusions on the quality of life\textsuperscript{26,30,41}; however, their application was time-consuming.

Similarly, the Index of Orthodontic Treatment Need (IOTN) was developed by linking the Dental Health Component, which assessed the type of malocclusion and treatment priority, to the Aesthetic Component, which assessed facial attractiveness, containing subjective and objective characteristics with potential utility in the social realm\textsuperscript{45}. The DAI considered the impact of dental characteristics in the individual’s psychosocial context and classified the severity of the malocclusions and the need for treatment\textsuperscript{42}. The index attributed different weights to each type of occlusal and dental alteration, considering the psychosocial impacts involved, and was recommended in the fourth edition of Oral Health Surveys: Basic methods\textsuperscript{52}. The Necessity Orthodontic Treatment Index (NOTI) determined the need for orthodontic treatment through the application of questionnaires and clinical evaluation\textsuperscript{48}; however, besides physical, sociocultural, and emotional information, the index used radiographs to complement the decision on the need for treatment, thereby limiting its applicability in epidemiological studies. The Risk of Malocclusion Index (ROMA) evaluated dental, physical, and functional characteristics, classified the malocclusions, and diagnosed the severity and need for orthodontic treatment\textsuperscript{56}. It can be performed by several health professionals and consists of a grid with results involving the psychosocial factors. Considering the importance of preventive actions, the Baby ROMA index, a variant of the ROMA index, classified the malocclusions and identified the risks involved in installation or aggravation of the problem, implying the need for early follow-up or intervention\textsuperscript{58,53}. The need and solubility of orthodontic treatment were evaluated using the Index of Complexity Outcome and Need (ICON), based on international parameters\textsuperscript{58}. Similarly, the Gottlieb index, Eismann index, Berg and Freudlund classification, Peer Assessment Rating index (PAR), and the Objective Grading System (OGS) & Comprehensive Clinical Assessment (CCA) index compared dental characteristics before and after orthodontic treatment and measured the effectiveness of orthodontic therapy\textsuperscript{56,39,40,46,47,53,54}.

The evolution of malocclusion indices shows that dental and skeletal changes caused by the pathology are often eclipsed by the psychological and social impact, which is considered extremely valuable in determining the need and priority for treatment. Therefore, indices that include clinical parameters but do not encompass the individual’s social and psychological context limit their application in the public health scenario.

**CONCLUSION**

Several malocclusion indices have been proposed over a century and although some of them present positive aspects and evaluate physical, functional, psychological, and social conditions, it is still a challenge to unanimously adopt an index that includes the requirements for assessing the severity, need for treatment, and impact of malocclusions on the individual’s quality of life with global applicability to public health policies.

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CONFLICTS OF INTERESTS
The authors declare no conflicts of interests.

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