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ORIGINAL ARTICLE

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# ACES: A new framework for the application of the 2018 periodontal status classification scheme to epidemiological survey data

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## Abstract

**Aim:** To propose a framework for consistently applying the 2018 periodontal status classification scheme to epidemiological surveys (Application of the 2018 periodontal status Classification to Epidemiological Survey data, ACES).

**Proposed Framework:** We specified data requirements and workflows for either completed or planned epidemiological surveys, utilizing commonly collected measures of periodontal status (clinical attachment levels [CAL], probing depths, bleeding on probing), as well as additional necessary variables for the implementation of the 2018 periodontal status classification (tooth loss due to periodontitis and complexity factors). Following detailed instructions and flowcharts, survey participants are classified as having periodontal health, gingivitis or periodontitis. Rates of edentulism must also be reported. In cases of periodontitis, instructions on how to compute the stage and

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extent are provided. Assessment of grade can be derived from CAL measurements (or from radiographic alveolar bone loss data) in relation to root length and the participant's age.

**Conclusions:** ACES is a framework to be used in epidemiological studies of periodontal status that (i) have been completed, and in which stage and grade according to the 2018 classification are inferred retroactively, or (ii) are being planned. Consistent use of the proposed comprehensive approach will facilitate the comparability of periodontitis prevalence estimates across studies.

**KEYWORDS**

2018 periodontitis classification, ACES, epidemiological survey, grade, stage

### Clinical Relevance

*Scientific rationale for study*: The application of the 2018 classification schemes for periodontal health, gingivitis and periodontitis to epidemiological data from completed, but also planned surveys, is challenging. This paper introduces a framework to be followed for this purpose.

*Principal findings*: We provide detailed instructions on how to classify participants of epidemiological studies according to the current gingivitis and periodontitis schemes and how to report periodontal prevalence data, depending on whether the survey is already completed or is being planned.

*Practical implications*: ACES (Application of the 2018 periodontal status Classification to Epidemiological Survey data) ensures a standardized reporting and valid comparisons of prevalence data across studies.

## 1 | INTRODUCTION

A new classification of periodontal diseases was introduced in 2018 (Caton et al., 2018), in which periodontitis cases are characterized according to their severity, extent and progression risk using a two-vector system defined by the stage and grade (Tonetti et al., 2018). The 2018 periodontal status classification has been already applied to both clinical cohorts (Alawaji et al., 2022; Costea et al., 2022; El Sayed et al., 2021; Graetz et al., 2019, 2020; Pianeta et al., 2021; Ravidà et al., 2020) and epidemiological surveys (Bongo et al., 2020; Botelho et al., 2020; Furuta et al., 2022; Germen et al., 2021; Ghassib et al., 2021; Iao et al., 2021; Jiao et al., 2021; Ju et al., 2021; Ke et al., 2022; Morales et al., 2021; Ortigara et al., 2021; Sodal et al., 2022; Stodle et al., 2021). Potential advantages of the new classification include a reported ability to reliably predict the incident tooth loss (El Sayed et al., 2021; Graetz et al., 2019; Ravidà et al., 2020) and a lower susceptibility to bias as compared to the Centers for Disease Control and Prevention/American Academy of Periodontology (CDC/AAP) classification when partial-mouth recording protocols are used (Botelho et al., 2020). Moreover, the assessment of grade involves the identification of common risk factors for periodontitis and facilitates interdisciplinary cooperation.

The 2018 periodontal status classification can be applied in daily practice by clinicians using already published flowcharts (Dietrich et al., 2019; Tonetti & Sanz, 2019). In contrast, the application of the 2018 classification to epidemiological surveys presents some significant challenges. First, it is usually not possible to accurately ascertain the reasons for tooth loss. Thus, the number of missing teeth due to periodontitis cannot be reliably determined. Notably, the few epidemiological studies applying the 2018 system so far have largely excluded tooth loss data from the assessment of stage (Bongo et al., 2020; Botelho et al., 2020; Furuta et al., 2022; Ghassib et al., 2021; Ju et al., 2021; Ke et al., 2022; Morales et al., 2021; Ortigara et al., 2021). However, most of those few studies that included tooth loss attributable to periodontitis in the assessment of stage have predominantly used assumptions rather than primary data (Graetz et al., 2019; Iao et al., 2021; Jiao et al., 2021; Sodal et al., 2022; Stodle et al., 2021). Second, complexity factors (including the presence of horizontal or vertical bone loss [BL], moderate or severe ridge defects, masticatory dysfunction and secondary occlusal trauma) are not routinely recorded in epidemiological surveys, resulting in a potential underestimation of the true prevalence of stage III or IV periodontitis. Consequently, a correct assignment of—and differential classification between—stage III and IV periodontitis based on clinical periodontal data alone may have been significantly impaired in the above studies, given the lack of information on periodontitis-related tooth loss and other complexity factors. Third, it appears that previously published epidemiological surveys using the 2018 classification encountered additional difficulty in the distinction between gingivitis and periodontitis, as none of them reported the presence of gingivitis cases despite the inclusion of young individuals (Bongo et al., 2020; Botelho et al., 2020; Ghassib et al., 2021; Iao et al., 2021; Ke et al., 2022; Ortigara et al., 2021). Lastly, a concrete framework on how to apply the 2018 scheme to epidemiological data has not been provided in the original publication (Tonetti et al., 2018) or the consensus reports (Caton et al., 2018; Chapple et al., 2018; Papapanou et al., 2018), allowing discrepancies due to different interpretations.

Indeed, the standardized application of the 2018 classification scheme and uniform reporting is essential in epidemiological surveys to ensure comparability of estimates of disease prevalence across different population samples. In this work, we introduce ACES (Application of the 2018 periodontal status Classification to Epidemiological Survey data) for applying the 2018 schemes in periodontitis epidemiology. ACES provides a framework for consistent implementation of the 2018 scheme to completed epidemiological surveys, which have commonly collected data on clinical attachment loss (CAL), probing depth (PD) and bleeding on probing (BoP), but can also guide how planned epidemiological surveys collect data to facilitate credible assessments of stage and grade that are objective and less dependent on inferences. This is achieved by incorporating targeted questions, along with the assessment of some relatively easily retrievable 'complexity factors'. Flowcharts are presented to facilitate the implementation of the proposed framework.

## 2 | PROPOSED FRAMEWORK FOR COMPLETED AND PLANNED EPIDEMIOLOGICAL SURVEYS

### 2.1 | Data collection in completed epidemiological surveys

To retroactively apply the proposed ACES framework to completed epidemiological surveys, the following data are required: an examination of periodontal status (preferably using a full-mouth, six-site/tooth recording protocol excluding third molars, as the extent of bias due to various partial recording protocols is yet unknown) comprising CAL and PD at both interdental and buccal/lingual sites. To distinguish between periodontal health and gingivitis, assessments of gingival inflammation (e.g. gingival index [GI] according to Löe and Silness (1963) or assessments of BoP) must also be available. Assessments of interproximal radiographic BL may be used as an alternative to interdental CAL, if available; it must be realized, however, that while interdental CAL measurements may tend to overestimate incipient (stage I) periodontitis in the presence of highly inflamed gingiva, the sensitivity of detection of incipient periodontitis based on radiographic assessments alone is impaired.

Among the complexity factors that are evaluated in the assessment of stage (Papapanou et al., 2018; Tonetti et al., 2018), we recommend that the following be used: (i) presence of natural teeth can be used to infer the number of opposing pairs of natural teeth (excluding third molars); this assessment will be solely based on anatomy (e.g. assumption that an upper first molar occludes with the lower first molar of the opposing quadrant) and does not require detailed occlusal data from bite registration, casts or intra-oral photographs. All pairs of opposing natural teeth are included in this assessment irrespective of whether the teeth are sound, decayed, filled or crowned. Note that the criterion of 'less than 10 opposing pairs of natural teeth', which is used to differentiate between stage III and stage IV periodontitis, is equivalent to the 'presence of less than 20 remaining natural teeth' and 'presence of less than 10 remaining natural teeth in one jaw'. (ii) If data on presence of class II or III furcation involvement (yes/no) are available, these can be used to distinguish between stage II and stage III periodontitis; in this case, also report prevalence disregarding furcation to facilitate meaningful comparisons across surveys. (iii) If radiographs are available, the presence of vertical BL ≥3 mm can also be considered to differentiate between stage II and stage III periodontitis.

To assess the grade, basic demographic variables (age and sex), current smoking status (non-smoker vs. smoker), number of cigarettes smoked per day (<10 vs. ≥10 cigarettes per day) and history of diabetes diagnosis and metabolic control (% haemoglobin [Hb] A1c [<7 vs. ≥7%]) are additionally required.

### 2.2 | Data collection in planned epidemiological surveys

To apply the proposed ACES framework to planned epidemiological surveys, the following data must be collected in addition to those required for completed surveys:

i. Assessment of the number of teeth lost due to periodontitis. While this information is not easily retrievable in epidemiological surveys, it may be approached indirectly either by specific questions, such as enquiring whether the extracted teeth were hypermobile (suggesting periodontitis-associated extractions), or by assessing the extent to which the remaining dentition is affected by periodontitis or restored in a manner suggesting that caries and endodontic pathologies may account for the majority of the tooth extractions. These inferences must conclude whether ≥5 or ≤4 teeth were lost as a result of periodontitis.
ii. Among the complexity factors that are evaluated in the assessment of stage (Papapanou et al., 2018; Tonetti et al., 2018), we suggest that the following data be routinely collected: furcation involvement class II or III (yes/no); tooth mobility degree ≥2 at ≥2 teeth (yes/no); bite collapse, drifting or flaring (yes/no; visual assessment); and fewer than 10 opposing pairs of natural teeth (as described for completed surveys). Note that the requirement for ≥2 teeth affected by hypermobility aims to minimize false positives due to measurement error or reasons of hypermobility other than by loss of periodontal tissue support. If radiographs are available, the presence of vertical BL ≥3 mm must also be recorded.

Detailed information on data processing in completed and planned epidemiological surveys is given in the online Appendix.

## 2.3 | Assessment of periodontal status and stage

In completed and planned epidemiological surveys, differentiation between mutually exclusive classes of edentulism, periodontal health, gingivitis, periodontitis and the 'non-classified' category is carried out in the same manner (Figure 1). Staging is performed according to Figure 2 in completed surveys and according to Figure 3 in planned surveys.

## 2.4 | Assessment of extent

In completed and planned epidemiological surveys, disease extent describes the percentage of teeth affected at the stage-defining severity level (Sanz et al., 2020). Calculation of the percentage of teeth affected must account for both the teeth fulfilling the respective severity thresholds (by means of interdental CAL or radiographic BL).

## 2.5 | Assessment of grade

In completed and planned epidemiological surveys, grade is determined as described in Papapanou et al. (2018). Direct assessment of grade requires availability of CAL or radiographic BL data from an earlier examination time point, to retrospectively assess progression over a 5-year period. Given that such data are usually not available in epidemiological surveys, indirect evidence of progression is calculated by computing the ratio of radiographic BL, expressed as a percent of the root length at the worst affected tooth, over the participant's age in years. Considering that radiographic BL data are commonly unavailable in epidemiological surveys, relative CAL as a percentage of the root length can be estimated using the following formula: relative CAL (%) $= 100 \times$ CAL (mm)/root length (mm). Root length data can be retrieved from two studies as suggested by Winkler et al. (2022): standard root lengths of a German cohort were reported for all teeth without distinction between sexes (Schumacher & Gente, 1995), see also Appendix Table 1. Sex-specific root lengths from mesial and distal sites of all teeth (excluding third molars) were reported for 732 randomly selected Swedish males and females (Salonen et al., 1991), see also Appendix Table 2.

## 2.6 | Reporting

Absolute and relative frequencies (for complex survey data, relative frequencies are adjusted for survey settings identified by the variables

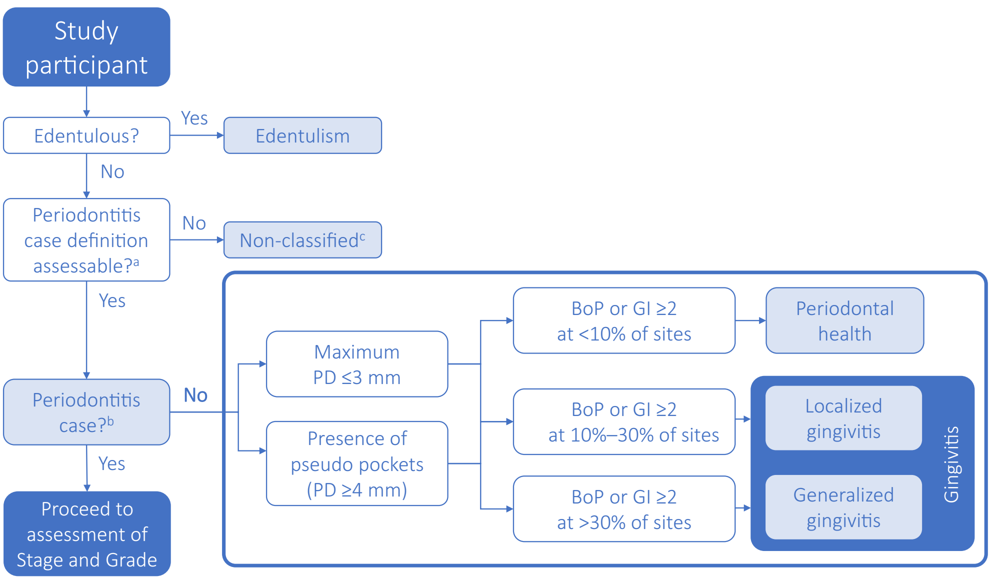


**FIGURE 1** Classification of study participants according to periodontal status in completed *and* planned epidemiological surveys (Chapple et al., 2018; Papapanou et al., 2018; Tonetti et al., 2018). First, edentulous subjects are identified. Second, the 'periodontitis case' criteria (i.e. interdental clinical attachment levels [CAL] ≥1 mm—or discernible bone loss [BL]—detectable at ≥2 non-adjacent teeth, or buccal or oral CAL ≥3 mm with concomitant pocketing >3 mm detectable at ≥2 teeth) are applied. Participants fulfilling the above criteria are further classified for stage and grade. If the periodontitis case criteria are *not* fulfilled, participants are classified into one of the following three groups: (i) 'Periodontal health', if bleeding on probing (BoP) or gingival index (GI) ≥2 occurs at <10% of the sites; (ii) 'Localized gingivitis', if BoP or GI ≥2 occurs at 10%–30% of the sites; or (iii) 'Generalized gingivitis' if BoP or GI ≥2 occurs at >30% of the sites. Cases with pseudo pockets (probing depth [PD] ≥4 mm in the absence of concomitant CAL) are classified as having either periodontal health or (localized or generalized) gingivitis based on the extent of gingival inflammation. It may be impossible to classify participants according to the above periodontitis case definition if (i) no interdental CAL measurements (or alveolar bone level measurements) are available, (ii) <2 non-adjacent teeth with interdental CAL measurements or <2 teeth with buccal or oral CAL and PD measurements are available. These participants should be referred to as 'non-classified', and assessments of stage, grade and extent are not performed. [a]Presence of ≥2 non-adjacent teeth with interdental CAL (or bone loss) measurements *or* ≥2 teeth with buccal or oral CAL and PD measurements. [b]Interdental CAL ≥1 mm (discernible bone loss) is detectable at ≥2 non-adjacent teeth *or* buccal or oral CAL ≥3 mm with pocketing >3 mm is detectable at ≥2 teeth. [c]No assessment of stage, extent and grade.

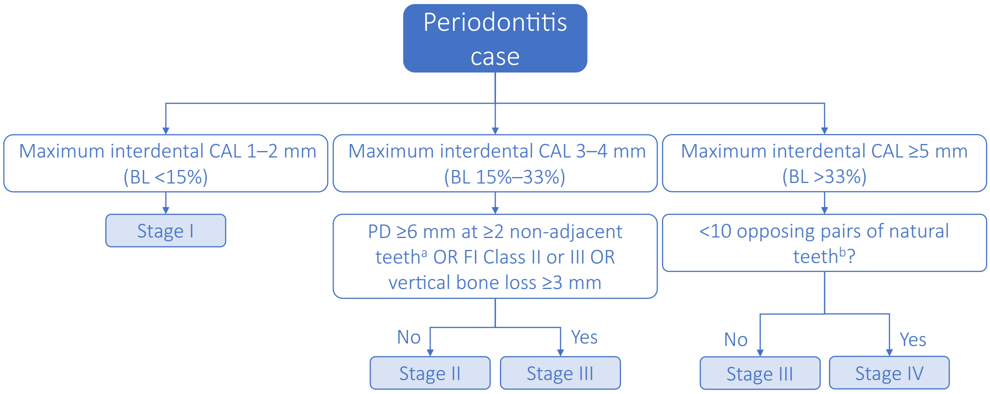


**FIGURE 2** Staging of periodontitis cases according to the 2018 classification scheme (Kornman & Papapanou, 2020; Papapanou et al., 2018; Tonetti et al., 2018) in completed epidemiological surveys. Stage is determined based on the severity of clinical attachment levels (CAL), using the maximum interdental CAL thresholds earlier defined (Papapanou et al., 2018). Participants presenting with probing depth (PD) ≥6 mm at ≥2 non-adjacent teeth (disregarding PDs at third molars and at distal surfaces of second molars) *or* furcation involvement class II or III *or* vertical bone loss ≥3 mm can further be upstaged from stage II to stage III. To differentiate between stages III and IV, the number of opposing pairs of natural teeth is considered, whereby <10 opposing pairs of natural teeth indicates stage IV. Given that reliable and unbiased information on reasons for tooth loss and other complexity factors is unavailable in completed surveys, we suggest refraining from using this criterion to determine Stage. [a]Disregard probing depths at third molars and at distal surfaces of second molars. [b]Equivalent to '<20 remaining natural teeth' and '<10 remaining natural teeth in one jaw'. BL, bone loss; FI, furcation involvement.

that contain information about the survey design, such as the sampling units and weights) for the following categories should be tabulated for the entire sample, including dentate *and* edentulous participants, as follows: 'Edentulism', 'Periodontal health', 'Gingivitis', 'Periodontitis' according to stage and grade, and 'Non-classified'. The denominator for frequency tabulations will be the total number of participants (edentulous and dentate). When oral health data are exclusively derived from dentate subjects, this should be clearly communicated.

Additional information about disease extent in staged periodontitis cases can be provided by tabulating localized versus generalized cases. Likewise, it should be clearly reported whether grade was based (i) on direct or indirect evidence of progression or (ii) on radiographic BL or relative CAL data.

Under the following link, information and syntax for various statistical programs implementing the ACES framework to epidemiological survey data will be provided: https://github.com/ACES-periodontitis.

## 3 | DISCUSSION

We present a framework for the implementation and reporting of the 2018 periodontal status classification scheme in completed and planned epidemiological surveys. Flowcharts are provided to facilitate the understanding of data-based decisions and their application to arrive at an inferred classification. We aimed to ensure a standardized reporting of the 2018 classification schemes to facilitate valid comparisons of prevalence data across different surveys.

Implementing the 2018 classification scheme to epidemiological data poses additional specific challenges beyond those encountered during its use in the ordinary clinical setting. An obvious one is the fact that the 2018 classification is primarily geared towards clinical practice and emphasizes the role of 'sound judgement' in the collective interpretation of the available data to arrive to a meaningful assessment of stage and grade. While this flexibility allows the individual clinician to correct potential misclassifications resulting from overly rigid rules, it is a clear disadvantage for a system utilized in epidemiological surveys that typically employ stringent protocols designed to minimize interpretational variability among multiple examiners. Indeed, individual elements of the 2018 classification do not readily lend themselves to automatic workflows. CAL due to iatrogenic reasons or root fracture, or tooth loss due to reasons other than periodontitis, are examples of features that make a lot of sense in the diagnosis of an individual patient but are difficult to utilize in the context of an epidemiological study. In this regard, an additional assessment of the stage during periodontal examination, which would allow for joint interpretation of available severity and complexity factors using 'sound clinical judgement to arrive at the most appropriate clinical diagnosis' (Tonetti et al., 2018), would enable comparisons between algorithm-based and clinician-based assessments of stage. Accordingly, planned surveys may provide valuable data about the discrepancy between algorithm-based and clinician-based assessments of stage.

A second feature that is commonly—albeit erroneously—mentioned as a disadvantage of the 2018 classification is the fact that a CAL ≥1 mm threshold is used to differentiate between a case of gingivitis, that is, a patient-based diagnosis of gingival inflammation in the presence of intact periodontal tissue support, and a true case of periodontitis, where loss of periodontal tissue support has indeed occurred. However, an accurate distinction between gingivitis and periodontitis, in both clinical and epidemiological settings, is not a

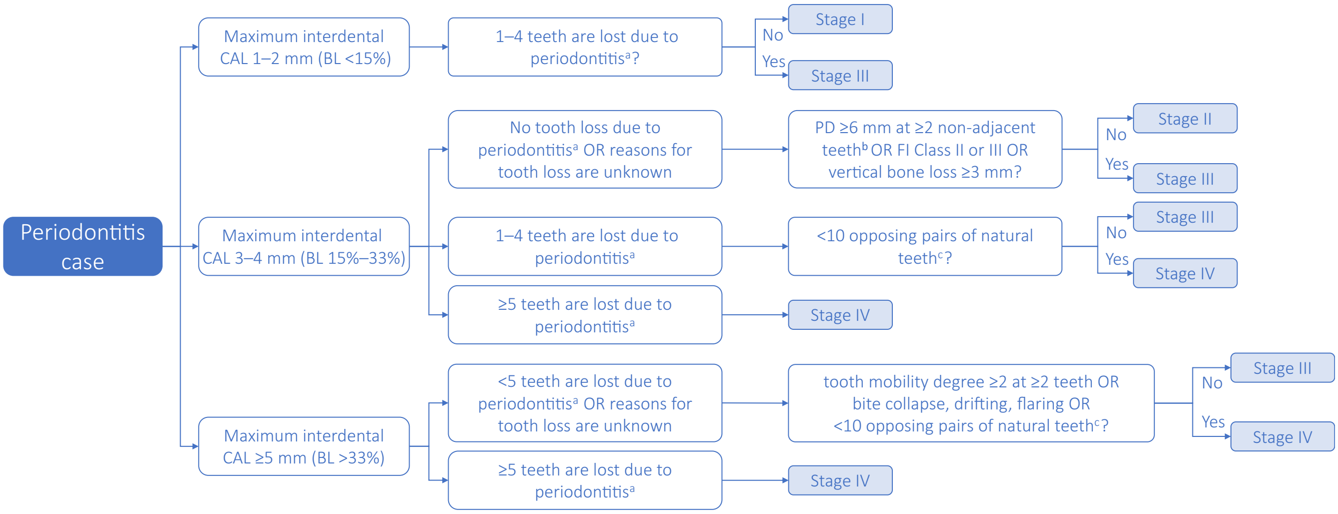


**FIGURE 3** Staging of periodontitis cases according to the 2018 classification scheme (Kornman & Papapanou, 2020; Papapanou et al., 2018; Tonetti et al., 2018) in planned epidemiological surveys. Stage is assessed a posteriori, using recorded data for (i) maximum interdental clinical attachment level (CAL) (or bone loss [BL]), (ii) tooth loss due to periodontitis and (iii) complexity factors, using software algorithms. Tooth loss due to periodontitis will be self-reported in response to targeted questions. Thus, the participant must (i) either explicitly confirm that the missing teeth were extracted as a result of periodontitis/advanced bone loss, or (ii) state that the missing teeth were mobile prior to extraction. We suggest to always record (i) the participant's statement regarding the reason for tooth loss and (ii) the presence of complexity factors in designated forms to facilitate an accurate and verifiable assessment of Stage. Figure 3 illustrates possible scenarios. Participants with maximum interdental CAL of 1–2 mm or BL/relative CAL <15%, initially assessed as stage I, are either assigned stage I or stage III, depending on whether no or 1–4 teeth are lost due to periodontitis, respectively. For participants with a maximum interdental CAL of 3–4 mm or BL/relative CAL 15%–33%, initially assessed as stage II, there are four possibilities: If no tooth loss due to periodontitis has occurred or if reasons for tooth loss are unknown, the participant is assigned either stage II or stage III, depending on whether at least one of the following three complexity factors is present: Probing depth (PD) ≥6 mm at ≥2 non-adjacent teeth (disregarding PDs at third molars and at distal surfaces of second molars) *or* furcation involvements class II or III are present *or* vertical bone loss ≥3 mm is noted. If 1–4 teeth are lost as a result of periodontitis, the participant is classified as either stage III or stage IV, depending on the number of opposing pairs of natural teeth. If ≥5 teeth are lost because of periodontitis, the participant is classified as stage IV. For participants with a maximum interdental CAL of ≥5 mm or with BL/relative CAL >33%, stage III is assigned at a minimum. If <5 teeth are lost because of periodontitis *or* if reasons for tooth loss are unknown, the presence of the following stage IV complexity factors is subsequently factored in: tooth mobility degree ≥2 at ≥2 teeth *or* bite collapse, drifting or flaring, *or* less than 10 opposing pairs of natural teeth. Accordingly, participants are assigned to either stage III or stage IV. If ≥5 teeth are lost because of periodontitis, stage IV is assigned. Alternatively, if adequate time is allotted to the periodontal examination, a trained examiner may define the stage according to the collective interpretation of the obtained clinical findings, as a specific point entry. Such a strategy will allow comparison between a clinically assessed stage and an algorithm-derived stage and will generate important research data. The third molars are not counted when calculating tooth loss. [a]Participant confirms that teeth were extracted because of periodontitis/advanced bone loss OR states that missing teeth were mobile prior to extraction. [b]Disregard probing depths at third molars and at distal surfaces of second molars. [c]Equivalent to '<20 remaining natural teeth' and '<10 remaining natural teeth in one jaw'. FI, furcation involvement.

novel problem created by the new classification but rather a consequence of the crude methodology currently used to detect incipient, frank periodontitis. As discussed earlier (Kornman & Papapanou, 2020), while the detection of periodontitis based on radiographic assessments of BL may be comparatively unambiguous, it is insensitive for the identification of incipient periodontitis that is crucial to detect, especially in young populations. In addition, the use of ionizing radiation for imaging purposes without a clear clinical indication is no longer defensible in today's medical practice and is, thus, inappropriate for screening purposes in epidemiological studies. Therefore, the detection of periodontitis inevitably relies on CAL measurementsthat are prone to substantial measurement error, especially when the cementoenamel junction (CEJ) is obscured because the gingival margin is located coronal to the CEJ or because of massive calculus deposits. Accordingly, calibration studies focusing on the correct identification of the CEJ and the location of the gingival margin are crucial, especially in cohorts of young age. Consequently, the accurate differentiation between gingivitis and stage I periodontitis is difficult, and the resulting estimates of the prevalence of either condition may be affected by significant bias. In older age groups, where gingival recession is more prevalent, visualization of the CEJ may generally facilitate more accurate measurements, although it may still be obscured by cervical abfractions or prosthetic restorations. In general, assessment of the prevalence of stage II–IV disease, which requires the presence of CAL ≥3 mm, is likely less prone to bias.

To partly overcome the above challenges, we have adapted certain elements of the staging process (Papapanou et al., 2018) for application to planned epidemiological surveys. Thus, we propose that, after initial assignment of the stage based on maximum interdental CAL, upstaging can occur either through the extent of periodontitis-associated tooth loss or by using a subset of complexity factors. As illustrated in Figure 3, the reasons for tooth loss are recorded as either unknown or known. If known, the number of teeth lost due to periodontitis must be determined (0, 1–4 or ≥5) and factored in upon the final determination of stage. However, this requires responses to validated questions related to reasons for tooth loss (e.g. that a participant confirms that teeth were extracted because of periodontitis/advanced bone loss; states that teeth were hypermobile before extraction; or reports a history of pain, history of endodontic treatment or presence of large restorations). An alternative approach was suggested based on PD and CAL from adjacent teeth (Li et al., 2021), but this is feasible only when individual teeth are missing. In another approach, all missing teeth excluding third molars in generalized stage III patients were considered as lost as a result of periodontitis (Graetz et al., 2019). There is an obvious risk, however, that this approach severely overestimates tooth loss due to periodontitis. In adult populations, caries and its sequelae were estimated to account for 35%–59% of tooth extractions as compared to 20%–38% of extractions due to periodontitis (Aida et al., 2009; Broers et al., 2022; Murray et al., 1996; Ong et al., 1996; Passarelli et al., 2020; Richards et al., 2005). Although tooth loss due to periodontitis increases with age, periodontitis still accounts for only 30%–70% of tooth loss in subjects aged 40+ years (Aida et al., 2009; Murray et al., 1996; Ong et al., 1996). Thus, it is obviously of paramount importance to distinguish between tooth loss due to periodontitis and extensive tooth loss consequent to other reasons (caries sequelae or restorative factors). Since third molars are often extracted for a variety of reasons, they are not included in the count of missing teeth.

Among the complexity factors listed in the consensus report (Papapanou et al., 2018), we selected a subset that appears to be most feasible to be considered to potentially modify the initially assigned stage in the context of an epidemiological survey. These include probing depths ≥6 mm, presence of furcation involvement class II or III, vertical BL ≥3 mm, tooth hypermobility (degree 2 or 3) at ≥2 teeth, bite collapse, drifting, or flaring and the number of opposing pairs of natural teeth. To minimize 'false positives', we opted to (i) disregard PDs at third molars and at distal surfaces of second molars from the computation of maximum PD, as they may be frequently affected by third molar impaction, and (ii) to also require the presence of deep pockets at ≥2 non-adjacent teeth.

In the absence of direct evidence of progression based on longitudinal CAL or BL measurements, or in the absence of any radiographic examination, indirect evidence of progression can be inferred (Winkler et al., 2022) by considering relative CAL as a percentage of the root length based on root length data provided by two studies (Salonen et al., 1991; Schumacher & Gente, 1995). While this seems to be an appealing method, grade assignment using CAL and standard root length data showed only fair to good/moderate agreement with the one based on relative BL data (kappa values ranged between 0.359 and 0.427) (Winkler et al., 2022). Thus, assessment of grade based on cross-sectional CAL data in the absence of radiographs has apparent shortcomings.

For planned surveys, we strongly suggest to separately report (i) the stage strictly based on maximum interdental CAL and (ii) the amended stage based on additional considerations including inferred periodontitis-associated tooth loss and/or complexity factors (according to Figure 3). Such data will provide valuable information about how much upstaging occurs due to tooth loss and/or complexity factors in different populations. Importantly, if severity and complexity factors cannot be collected with the necessary precision, stage should be determined on the basis of maximum interdental CAL, PDs, furcation involvement class II or III, vertical BL ≥3 mm and the number of opposing pairs of natural teeth (Figure 2).

When reporting disease prevalence estimates according to the 2018 classification schemes, results generated by the use of other periodontitis case definitions, that is, the CDC/AAP case definition (Eke, Page, et al., 2012), as well as the prevalence of maximum PD or CAL at certain threshold levels (Holtfreter et al., 2015) should also be reported. This will facilitate inferences on secular trends based on available data derived prior to the 2018 classification scheme. In addition, distributions of continuous variables quantifying disease severity (i.e. mean PD or mean CAL) and extent (e.g. the percentage of sites with PD or CAL at certain thresholds) should also be reported. Reporting of the reason for 'non-classified cases', that is, whether it was due to non-readability of CAL, or presence of too few qualifying teeth (as required by the periodontitis case definition), is advisable.

To provide health policymakers and stakeholders with valid and reliable periodontal prevalence data, the prevalence of edentulism must be concomitantly reported. Regrettably, several epidemiological surveys (Eke et al., 2016; Eke, Dye, et al., 2012; Schützhold et al., 2015) exclusively reported periodontal prevalence among dentate subjects, which obviously distorts the true national or regional oral health status. Illustrating this crucial point, the repeated cross-sectional surveys in the Jönköping county in Sweden showed a decreasing rate of edentulism over four decades but a relatively unchanged rate of severe periodontitis (Hugoson et al., 2008). Obviously, tooth retention among people with severe periodontitis may partly underlie these secular trends, which would have remained undetected if only dentate participants had been included in the tabulated frequency distributions.

It is worth pondering whether the requirement for discernible interproximal CAL at ≥2 non-adjacent teeth, which was obviously introduced to minimize false positives, should rather be redefined as a requirement of presence of interproximal CAL at ≥2 non-adjacent *tooth surfaces*. Indeed, while two adjacent interproximal surfaces on two consecutive teeth may be considered interdependent, in terms of the aetiology of attachment loss, CAL affecting non-adjacent surfaces of two adjacent teeth are not.

The application of the ACES framework to epidemiological survey datasets hinges upon fulfilment of certain requirements related to the examination protocol and the type of periodontal measurements collected, as both aspects have a major impact on the estimation of disease prevalence. While full-mouth, six-site/tooth recording protocols are optimal, least prone to computation of biased prevalence estimates (Holtfreter et al., 2015) and highly recommended for planned epidemiological surveys employing the 2018 classification scheme, partial-mouth recordings (based on selected teeth and sites, including non-interdental *and* interdental sites) can also be considered because of logistical and time allocation restrictions inherent in epidemiological surveys. Interestingly, Botelho et al. (2020) reported that computation of stage based on maximum interdental CAL was less susceptible to bias because of partial-mouth recording protocols than the CDC/AAP classification. Availability of data reflecting prevalent clinical inflammation (GI or BoP) is obviously necessary to distinguish between health and gingivitis. Likewise, lack of information on complexity factors or periodontitis-associated tooth loss may result in underestimation of the prevalence of stage III or stage IV periodontitis.

Interestingly, the 2018 classification has already been applied in risk-factor studies, where periodontitis was considered as either the exposure or the outcome (Germen et al., 2021; Iwasaki et al., 2019; Ke et al., 2022). It must be realized, however, that grade already incorporates age, presence and intensity of smoking, and history of diabetes and metabolic control. Therefore, its usage in risk factor models may pose problems because such models usually require adjustments for the same variables.

From a health policy point of view, epidemiological surveys of periodontal conditions are conducted to pursue three major aims: (i) to generate prevalence estimates and quantify the disease burden by gingivitis and periodontitis, thereby defining treatment needs; (ii) to assess the need for preventive and therapeutic interventions; and (iii) to assess periodontal treatment outcomes in the general population. It must be realized that the assessment of stage, due to its irreversible nature, is not well suited to capture treatment needs, treatment outcomes in persons reporting a history of periodontal treatment or the effects of various interventions. Therefore, additional variables beyond the assessment of stage and grade need to be incorporated in epidemiologic surveys to reflect these important aspects.

In addition to clinical studies, which estimate treatment efficacy, well-designed registry or population-based studies provide valuable data on treatment efficiency. However, as registry data are not widely available and provide only a limited choice of variable selection, population-based studies provide a useful alternative to retrieve comprehensive information on participant characteristics and treatment outcomes under the conditions of general dental practices. However, it must be noted that data on history of periodontal treatment in epidemiological surveys are subject to recall bias, and reflect uncertainties related to the type and quality of care delivered, the timing of delivery and the provision of effective maintenance. Thus, development of pertinent and precise questions is required in future surveys, so that policy stakeholders may obtain a more accurate assessment of the outcomes of periodontal therapy at the population level.

In conclusion, the presented ACES framework standardizes the application and reporting of the 2018 classification scheme and can be applied to already collected datasets as well as in planned surveys. While this framework facilitates a consistent implementation of the 2018 classification scheme, a comprehensive reporting of the methodological details of the surveys as well as the exact computational steps involved in the application of the ACES framework is essential for correct data interpretation.

## AUTHOR CONTRIBUTIONS

B.H., K.K., K.B., M.T., M.S., K.K., S.J., G.A., T.K., J.K. and P.N.P. substantially contributed to the conception or design of the work. B.H., K.K., K.B., H.V., T.K. and J.K. contributed to the acquisition, analysis or interpretation of data. B.H., K.K., K.B., J.K., T.K., J.K. and P.N.P. drafted the manuscript. M.T., M.S., K.K., S.J., G.A., H.V. and J.K. revised the manuscript critically for important intellectual content. All authors approved the final version of the manuscript and are accountable for all aspects of the work.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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## DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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## REFERENCES

Aida, J., Morita, M., Akhter, R., Aoyama, H., Masui, M., & Ando, Y. (2009). Relationships between patient characteristics and reasons for tooth extraction in Japan. *Community Dental Health*, *26*(2), 104–109.

Alawaji, Y. N., Alshammari, A., Mostafa, N., Carvalho, R. M., & Aleksejuniene, J. (2022). Periodontal disease prevalence, extent, and risk associations in untreated individuals. *Clinical and Experimental Dental Research*, *8*(1), 380–394. https://doi.org/10.1002/cre2.526

Bongo, A. S., Brustad, M., Oscarson, N., & Jonsson, B. (2020). Periodontal health in an indigenous Sami population in Northern Norway: A cross-sectional study. *BMC Oral Health*, *20*(1), 104. https://doi.org/10.1186/s12903-020-01098-3

Botelho, J., Machado, V., Proenca, L., & Mendes, J. J. (2020). The 2018 periodontitis case definition improves accuracy performance of full-mouth partial diagnostic protocols. *Scientific Reports*, *10*(1), 7093. https://doi.org/10.1038/s41598-020-63700-6

Broers, D. L. M., Dubois, L., de Lange, J., Su, N., & de Jongh, A. (2022). Reasons for tooth removal in adults: A systematic review. *International Dental Journal*, *72*(1), 52–57. https://doi.org/10.1016/j.identj.2021.01.011

Caton, J. G., Armitage, G., Berglundh, T., Chapple, I. L. C., Jepsen, S., Kornman, K. S., Mealey, B. L., Papapanou, P. N., Sanz, M., & Tonetti, M. S. (2018). A new classification scheme for periodontal and peri-implant diseases and conditions – Introduction and key changes from the 1999 classification. *Journal of Clinical Periodontology*, *45*-(Suppl. 20), S1–S8. https://doi.org/10.1111/jcpe.12935

Chapple, I. L. C., Mealey, B. L., Van Dyke, T. E., Bartold, P. M., Dommisch, H., Eickholz, P., Geisinger, M. L., Genco, R. J., Glogauer, M., Goldstein, M., Griffin, T. J., Holmstrup, P., Johnson, G. K., Kapila, Y., Lang, N. P., Meyle, J., Murakami, S., Plemons, J., Romito, G. A., … Yoshie, H. (2018). Periodontal health and gingival diseases and conditions on an intact and a reduced periodontium: Consensus report of workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *Journal of Clinical Periodontology*, *45*(Suppl. 20), S68–S77. https://doi.org/10.1111/jcpe.12940

Costea, C. A., Christodorescu, R., Soancă, A., Roman, A., Micu, I. C., Stratul, S. I., Rusu, D., Popescu, D. M., Popa-Wagner, A., & Bulboacă, A. E. (2022). Periodontitis in ischemic stroke patients: Case definition challenges of the new classification scheme (2018). *Journal of Clinical Medicine*, *11*(3), 520. https://doi.org/10.3390/jcm11030520

Dietrich, T., Ower, P., Tank, M., West, N. X., Walter, C., Needleman, I., Hughes, F. J., Wadia, R., Milward, M. R., Hodge, P. J., Chapple, I. L. C., & British Society of Periodontology. (2019). Periodontal diagnosis in the context of the 2017 classification system of periodontal diseases and conditions – Implementation in clinical practice. *British Dental Journal*, *226*(1), 16–22. https://doi.org/10.1038/sj.bdj.2019.3

Eke, P. I., Dye, B. A., Wei, L., Thornton-Evans, G. O., Genco, R. J., CDC Periodontal Disease Surveillance workgroup: James Beck (University of North Carolina, Chapel Hill, USA), Gordon Douglass (Past President, American Academy of Periodontology), Roy Page (University of Washin), & James Beck, G. D. R. P. (2012). Prevalence of periodontitis in adults in the United States: 2009 and 2010. *Journal of Dental Research*, *91*(10), 914–920. https://doi.org/10.1177/0022034512457373

Eke, P. I., Page, R. C., Wei, L., Thornton-Evans, G., & Genco, R. J. (2012). Update of the case definitions for population-based surveillance of periodontitis. *Journal of Periodontology*, *83*(12), 1449–1454. https://doi.org/10.1902/jop.2012.110664

Eke, P. I., Wei, L., Borgnakke, W. S., Thornton-Evans, G., Zhang, X., Lu, H., McGuire, L., & Genco, R. J. (2016). Periodontitis prevalence in adults >/= 65 years of age, in the USA. *Periodontology 2000*, *72*(1), 76–95. https://doi.org/10.1111/prd.12145

El Sayed, N., Rahim-Wostefeld, S., Stocker, F., Behnisch, R., Eickholz, P., & Pretzl, B. (2021). The 2018 classification of periodontal diseases: Its predictive value for tooth loss. *Journal of Periodontology*, *93*, 560–569. https://doi.org/10.1002/JPER.21-0211

Furuta, M., Takeuchi, K., Takeshita, T., Shibata, Y., Suma, S., Kageyama, S., Asakawa, M., Shimazaki, Y., Hata, J., Ninomiya, T., & Yamashita, Y. (2022). Baseline periodontal status and modifiable risk factors are associated with tooth loss over a 10-year period: Estimates of population attributable risk in a Japanese community. *Journal of Periodontology*, *93*(4), 526–536. https://doi.org/10.1002/JPER.21-0191

Germen, M., Baser, U., Lacin, C. C., Firatli, E., Issever, H., & Yalcin, F. (2021). Periodontitis prevalence, severity, and risk factors: A comparison of the AAP/CDC case definition and the EFP/AAP classification. *International Journal of Environmental Research and Public Health*, *18*(7), 3459. https://doi.org/10.3390/ijerph18073459

Ghassib, I. H., Batarseh, F. A., Wang, H. L., & Borgnakke, W. S. (2021). Clustering by periodontitis-associated factors: A novel application to NHANES data. *Journal of Periodontology*, *92*(8), 1136–1150. https://doi.org/10.1002/JPER.20-0489

Graetz, C., Mann, L., Krois, J., Salzer, S., Kahl, M., Springer, C., & Schwendicke, F. (2019). Comparison of periodontitis patients' classification in the 2018 versus 1999 classification. *Journal of Clinical Periodontology*, *46*(9), 908–917. https://doi.org/10.1111/jcpe.13157

Graetz, C., Schwalbach, M., Seidel, M., Geiken, A., & Schwendicke, F. (2020). Oral health-related quality of life impacts are low 27 years after periodontal therapy. *Journal of Clinical Periodontology*, *47*(8), 952–961. https://doi.org/10.1111/jcpe.13324

Holtfreter, B., Albandar, J. M., Dietrich, T., Dye, B. A., Eaton, K. A., Eke, P. I., Papapanou, P. N., Kocher, T., & Joint EU/USA Periodontal Epidemiology Working Group. (2015). Standards for reporting chronic periodontitis prevalence and severity in epidemiologic studies: Proposed standards from the Joint EU/USA Periodontal Epidemiology Working Group. *Journal of Clinical Periodontology*, *42*(5), 407–412. https://doi.org/10.1111/jcpe.12392

Hugoson, A., Sjodin, B., & Norderyd, O. (2008). Trends over 30 years, 1973–2003, in the prevalence and severity of periodontal disease. *Journal of Clinical Periodontology*, *35*(5), 405–414. https://doi.org/10.1111/j.1600-051X.2008.01225.x

Iao, S., Pei, X., Ouyang, X., Liu, J., Liu, W., & Cao, C. (2021). Natural progression of periodontal diseases in Chinese villagers based on the 2018 classification. *Journal of Periodontology*, *92*(9), 1232–1242. https://doi.org/10.1002/JPER.20-0199

Iwasaki, M., Kimura, Y., Ogawa, H., Yamaga, T., Ansai, T., Wada, T., Sakamoto, R., Ishimoto, Y., Fujisawa, M., Okumiya, K., Miyazaki, H., & Matsubayashi, K. (2019). Periodontitis, periodontal inflammation, and mild cognitive impairment: A 5-year cohort study. *Journal of Periodontal Research*, *54*(3), 233–240. https://doi.org/10.1111/jre.12623

Jiao, J., Jing, W., Si, Y., Feng, X., Tai, B., Hu, D., Lin, H., Wang, B., Wang, C., Zheng, S., Liu, X., Rong, W., Wang, W., Li, W., Meng, H., & Wang, X. (2021). The prevalence and severity of periodontal disease in Mainland China: Data from the Fourth National Oral Health Survey (2015–2016). *Journal of Clinical Periodontology*, *48*(2), 168–179. https://doi.org/10.1111/jcpe.13396

Ju, X., Harford, J., Luzzi, L., & Jamieson, L. M. (2021). Prevalence, extent and severity of periodontitis among Australian older adults: Comparison of two generations. *Journal of Periodontology*, *93*, 1387–1400. https://doi.org/10.1002/JPER.21-0458

Ke, L., Nogueira, G., & Thomson, W. M. (2022). Influence of case definitions on epidemiological estimates of periodontitis prevalence and its associations with smoking and OHRQoL. *Community Dentistry and Oral Epidemiology*, *51*, 194–200. https://doi.org/10.1111/cdoe.12726

Kornman, K. S., & Papapanou, P. N. (2020). Clinical application of the new classification of periodontal diseases: Ground rules, clarifications and "gray zones". *Journal of Periodontology*, *91*(3), 352–360. https://doi.org/10.1002/JPER.19-0557

Li, A., Chen, L., Thomas, R. Z., van der Velden, U., Amaliya, A., van der Sluis, L. W. M., Schuller, A. A., & Tjakkes, G. E. (2021). Periodontal breakdown inter-tooth relationships in estimating periodontitis-related tooth loss. *Journal of Dentistry*, *112*(103), 755. https://doi.org/10.1016/j.jdent.2021.103755

Löe, H., & Silness, J. (1963). Periodontal disease in pregnancy. I. prevalence and severity. *Acta Odontol Scand*, *21*, 533–551. https://doi.org/10.3109/00016356309011240

Morales, A., Strauss, F. J., Hämmerle, C. H. F., Romandini, M., Cavalla, F., Baeza, M., Sanz, M., & Gamonal, J. (2021). Performance of the 2017 AAP/EFP case definition compared with the CDC/AAP definition in population-based studies. *Journal of Periodontology*, *93*, 1003–1013. https://doi.org/10.1002/JPER.21-0276

Murray, H., Locker, D., & Kay, E. J. (1996). Patterns of and reasons for tooth extractions in general dental practice in Ontario, Canada. *Community Dentistry and Oral Epidemiology*, *24*(3), 196–200. https://doi.org/10.1111/j.1600-0528.1996.tb00841.x

Ong, G., Yeo, J. F., & Bhole, S. (1996). A survey of reasons for extraction of permanent teeth in Singapore. *Community Dentistry and Oral Epidemiology*, *24*(2), 124–127. https://doi.org/10.1111/j.1600-0528.1996.tb00828.x

Ortigara, G. B., Mario Ferreira, T. G., Tatsch, K. F., Romito, G. A., Ardenghi, T. M., Sfreddo, C. S., & Moreira, C. H. C. (2021). The 2018 EFP/AAP periodontitis case classification demonstrates high agreement with the 2012 CDC/AAP criteria. *Journal of Clinical Periodontology*, *48*(7), 886–895. https://doi.org/10.1111/jcpe.13462

Papapanou, P. N., Sanz, M., Buduneli, N., Dietrich, T., Feres, M., Fine, D. H., & Tonetti, M. S. (2018). Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *Journal of Clinical Periodontology*, *45*(Suppl. 20), S162–S170. https://doi.org/10.1111/jcpe.12946

Passarelli, P. C., Pagnoni, S., Piccirillo, G. B., Desantis, V., Benegiamo, M., Liguori, A., Papa, R., Papi, P., Pompa, G., & D'Addona, A. (2020). Reasons for tooth extractions and related risk factors in adult patients: A cohort study. *International Journal of Environmental Research and Public Health*, *17*(7), 2575. https://doi.org/10.3390/ijerph17072575

Pianeta, R., Iniesta, M., Castillo, D. M., Lafaurie, G. I., Sanz, M., & Herrera, D. (2021). Characterization of the subgingival cultivable microbiota in patients with different stages of periodontitis in Spain and Colombia. A cross-sectional study. *Microorganisms*, *9*(9), 1940. https://doi.org/10.3390/microorganisms9091940

Ravidà, A., Troiano, G., Qazi, M., Saleh, M. H. A., Lo Russo, L., Greenwell, H., Giannobile, W. V., & Wang, H. L. (2020). Development of a nomogram for the prediction of periodontal tooth loss using the staging and grading system: A long-term cohort study. *Journal of Clinical Periodontology*, *47*(11), 1362–1370. https://doi.org/10.1111/jcpe.13362

Richards, W., Ameen, J., Coll, A. M., & Higgs, G. (2005). Reasons for tooth extraction in four general dental practices in South Wales. *British Dental Journal*, *198*(5), 275–278. https://doi.org/10.1038/sj.bdj.4812119

Salonen, L. W., Frithiof, L., Wouters, F. R., & Hellden, L. B. (1991). Marginal alveolar bone height in an adult Swedish population. A radiographic cross-sectional epidemiologic study. *Journal of Clinical Periodontology*, *18*(4), 223–232. https://doi.org/10.1111/j.1600-051x.1991.tb00419.x

Sanz, M., Papapanou, P. N., Tonetti, M. S., Greenwell, H., & Kornman, K. (2020). Guest editorial: Clarifications on the use of the new classification of periodontitis. *Journal of Clinical Periodontology*, *47*(6), 658–659. https://doi.org/10.1111/jcpe.13286

Schumacher, G.-H., & Gente, M. (1995). *Odontographie – Anatomie der Zähne und des Gebisses* (5th ed.). Huethig GmbH.

Schützhold, S., Kocher, T., Biffar, R., Hoffmann, T., Schmidt, C. O., Micheelis, W., Jordan, R., & Holtfreter, B. (2015). Changes in prevalence of periodontitis in two German population-based studies. *Journal of Clinical Periodontology*, *42*(2), 121–130. https://doi.org/10.1111/jcpe.12352

Sodal, A. T. T., Hove, L. H., Diep, M. T., Skudutyte-Rysstad, R., & Koldsland, O. C. (2022). Periodontal conditions in a 65-year-old population and prevalence of periodontitis according to three different bone level thresholds. *BMC Oral Health*, *22*(1), 246. https://doi.org/10.1186/s12903-022-02276-1

Stodle, I. H., Verket, A., Hovik, H., Sen, A., & Koldsland, O. C. (2021). Prevalence of periodontitis based on the 2017 classification in a Norwegian population: The HUNT study. *Journal of Clinical Periodontology*, *48*(9), 1189–1199. https://doi.org/10.1111/jcpe.13507

Tonetti, M. S., Greenwell, H., & Kornman, K. S. (2018). Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. *Journal of Clinical Periodontology*, *45*(Suppl. 20), S149–S161. https://doi.org/10.1111/jcpe.12945

Tonetti, M. S., & Sanz, M. (2019). Implementation of the new classification of periodontal diseases: Decision-making algorithms for clinical practice and education. *Journal of Clinical Periodontology*, *46*(4), 398–405. https://doi.org/10.1111/jcpe.13104

Winkler, P., Dannewitz, B., Nickles, K., Petsos, H., & Eickholz, P. (2022). Assessment of periodontitis grade in epidemiological studies using interdental attachment loss instead of radiographic bone loss. *Journal of Clinical Periodontology*, *49*(9), 854–861. https://doi.org/10.1111/jcpe.13679

## SUPPORTING INFORMATION

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