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Periodontal Probing Depth Trajectory in 10 Years of Follow-Up as Associated With Tooth Loss

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ABSTRACT

Aim: To elucidate whether ranked probing depth (PD) data translate into ranked PD outcomes after 10 years of follow-up and the associated tooth loss.

Materials and Methods: From the Study of Health in Pomerania (SHIP-START), all participants were retrospectively included with complete PD measurements in both baseline and 10-year follow-up, comprising 1887 participants. The trajectory of percentile-based quintiles of mean PD measurements was followed.

Results: Quintiles of mean PD at baseline were, in a dose dependent manner, associated with the number of teeth at baseline, number of teeth after 10 years and involved risk of tooth loss. The trajectory of membership to individual PD quintiles indicated that the majority of participants remained in or near their baseline quintile after reaching the 10-year end analysis. Periodontal risk factors assessed at baseline continued to affect PD outcomes at follow-up. Two categories of tooth loss were identified: 1–2 teeth lost versus ≥ 3 teeth and differentiated by baseline PD.

Conclusion: PD severity ranked within this population translates, in a dose-dependent manner, to follow-up tooth loss even after many years. This underlines the prospective importance of pocket probing in the dental practice. Ranked PD offers a simple measure to identify patients at high risk of tooth loss.

In the UK all dentists do a BPE examination which is a very crude screening assessment. It is very uncommon for generalists to record CAL. In fact I'd go as far as to say it is unheard of.

as quoted by a London high street dentist.

1 | Introduction

Periodontitis is a common inflammatory disease caused by oral bacteria, resulting in destruction of the supporting tissues of the teeth, which is observable by pathological pocket formation, concomitant attachment loss and eventual tooth loss. The assessment of pocket probing depth (PD) is one of the most important aspects of diagnosis, classification and treatment of periodontitis. When left untreated, the deepening of periodontal pockets may be extensive and longitudinal, occurring over long periods with all its pathological sequelae (Elashiry et al. 2019). With prolonged life expectancy and increasing prevalence of periodontitis, dental practitioners have a duty of care to screen, diagnose and appropriately treat periodontal diseases.

Since periodontal inflammation may lead to a loss of the supporting periodontium, measuring the loss of this attachment is a key criterion for classifying the disease stage and grade predicting future tissue destruction (Van der Velden et al. 2006; Tonetti, Greenwell, and Kornman 2018). Both clinical attachment level

(CAL) and PD have been used to determine the periodontal disease status. PD quantifies the current periodontal status without accounting for gingival margin changes. The gingival margin does not represent a definite benchmark, as it is given with respect to the cemento-enamel junction. Thus, any PD change across a longer forecasting horizon may not be predictable. Nevertheless, a recent meta-analysis considered high PD as a predictor of tooth loss (Helal et al. 2019).

CAL is a diagnostic parameter to quantify periodontal attachment over longer time periods, but periodontal PD is rather preferred for assessing the current periodontal state. The 2017 World Workshop standardized periodontal aspects insofar as the interdental CAL determines the current disease classification and PD the complexity of treatment (Tonetti, Greenwell, and Kornman 2018). When left untreated, a patient's CAL will increase during the life span, subsuming all the positive and negative risks accumulated with age. The progress in PD is more distracting and less pronounced, as it is an acute inflammation-related measure (Pink et al. 2015). PD has commonly been used first and foremost and is still recorded by general dentists and periodontists, whereas CAL is not routinely assessed in daily dental practice (Page and Eke 2007; Mdala et al. 2014). For the general dental practice, the observation made by Chapple (Chapple 2009) still applies, namely that measurements of periodontal PD, bleeding on probing (BOP), plaque and tooth mobility remain the main diagnostic cornerstones of clinical periodontitis diagnostics (Sharma et al. 2018). Thus, a high proportion of screening, diagnostic and monitoring methods were and are based upon PD measurements (Bailey et al. 2016; Saleem 2019; Dietrich et al. 2019).

Many epidemiological studies have used the CPITN (Community Periodontal Index of Treatment Need) to classify periodontitis (GBD et al. 2020). This index estimates periodontal disease prevalence and severity based on PD and the state of periodontal tissues. Although this method is limited, as it only assesses PD, it is used throughout the world because it is easy to perform and is easily understandable by patients (Nazir et al. 2020). It is also widely used for patient screening in daily practice. In many healthcare systems, a (modified) CPI code is used by general dentists for screening, and if a need for treatment is identified, more comprehensive assessments are carried out, sometimes also limited to PD recording. In the United Kingdom, BPE (Basic Periodontal Examination) follows such a scheme (British Society of Periodontology 2011; Palmer and Floyd 2023); in the Netherlands, DPSI (Dutch Periodontal Screening Index) is in use (Van der Velden 2009).

In order to establish personalized treatment strategies, it is central to develop methods feasible for specific practices and predicting future outcomes such as tooth loss. Clinicians must identify which patients are at higher or lower risk of losing teeth. Studies by Schwendicke et al. (2018, 2021) revealed significant challenges in this area. These researchers concluded that predictive models trained on data from one dental school could not be reliably applied to other institutions. This lack of transferability is a direct result of the fact that dentists in different schools treat distinct patient populations with varying characteristics and risk factors. Thus, developing clinically useful predictive models with broad applicability across different dental practices and patient groups remains a significant challenge. Instead, using a reference population with the help of practice-specific electronic health records can be constructed, which mirror the underlying driving biological and social risk factors. These percentile charts, for example based on PD, will help narrow down high-risk patients and target treatment resources (Schwahn et al. 2004). Such percentile charts can be based on data from single practices with similar risk profiles, given that enough data are available (Samietz et al. 2015). This approach allows the practice to offer treatment according to available internal resources, which should be practical, feasible and outcome-relevant (Raittio et al. 2024).

Thus, the question arises whether practitioners can use baseline PD for the prediction of tooth loss. In this study, we wondered whether baseline PD and its determinants do affect both the PD outcome after 10 years and the associated tooth loss. We replaced comparisons of averaged PD measures between baseline and follow-up by PD trajectories taken from percentile-based rankings of PD distributions and to their ranked individual follow-up positions.

Our objective was to find out whether a certain baseline PD ranking position would change after 10 years to another rank position and whether such transition determines tooth loss and could be used for the prognosis of tooth loss.

2 | Materials and Methods

2.1 | Study Design

The baseline examination of the Study of Health in Pomerania (SHIP-START-0) cohort comprised residents in the north-eastern German area of West Pomerania (Völzke et al. 2022). Randomly drawn from local registries, 4308 Caucasian subjects participated (1997–2001). The follow-up was conducted 10 years later (SHIP-START-2), launched in 2008, comprising 2333 subjects aged 30–90 years. Here, only participants of both study parts were analysed with complete PD measurements, resulting in a final number of 1887 participants, of whom 895 were male and 992 female. The STROBE guidelines were followed in this report.

2.2 | Periodontal Measurements

Periodontal assessment included PD, CAL, dental plaque, BOP and the number of teeth. For the number of teeth, all fully erupted teeth were assessed excluding third molars. The periodontal examination was carried out on either the left- or right-side quadrants, and the examination side was changed from participant to participant. CAL and PD were assessed with a periodontal probe (PCP11, HuFriedy, Chicago, IL) at the mesio-buccal, disto-buccal, mid-buccal and mid-lingual aspects on each selected tooth and recorded as whole millimeters.

2.3 | Socioeconomic, Anthropometric and Laboratory Data

Indicators of socio-demographic variables were taken from the health-related interview or personal questionnaires. Education was categorized according to the final school grade (< 10 years, 10 years, > 10 years), and smoking was categorized into never, quit and current smokers. Self-reported appreciation of dental health was assessed by the question 'How would you rate the health status of your teeth?' and then divided into three categories: very good/good, fair or poor. Anthropometric data were measured as follows: body weight to the nearest 0.10 kg, height to the nearest 1 cm and waist and hip circumferences to the nearest 0.5 cm (measuring devices from SOEHNLE, Murrhardt, Germany). Waist circumference (WC) was measured between the lower ribs and the iliac crest, and hip circumference at the level of the largest lateral extension of the hips or over the buttocks. Body mass index (BMI) was calculated as weight/(height)^2, and the waist-to-height ratio (WHtR) was also calculated. Glycated hemoglobin (HbA1c) and fibrinogen according to Clauss were measured by standard laboratory methods.

2.4 | Statistical Analyses

Mann–Whitney tests or contingence tables were used to assess differences between baseline and follow-up data in continuous and categorical variables, respectively. Based on SHIP-START-0 (baseline) or SHIP-START-2 (follow-up), PD measurements were used as continuous variables or stratified into quintiles derived from ranked mean PD figures. A specific quintile rank indicated then the proportion of participants whose PD compared with those of the counterpart quintiles (for explanation, see Figure S1). Generalized linear models were applied for regression analyses on the Gaussian (normal) variables, or, in the case of PD extent (%), link logit models were used from the binomial family with robust variance estimates. To this end, the percentage figures were transformed to proportions ranging from 0 to 1. For incident tooth loss, negative binomial regression was used, including individual age differences as offset variables (median age difference 10.4 years). All estimates were provided with 95% confidence intervals (CIs) or bands. Analyses were performed using STATA 14.0 software (Stata Corp. LLP, College Station, USA).

3 | Results

Between the two assessment periods, namely SHIP-START-0 and SHIP-START-2, the participants had aged by 10 years. As we only included participants who were identical at baseline and follow-up data acquisition points, the figures presented in Table 1 are directly comparable. Periodontal measures such as PD and CAL worsened during the intervening period, but the extent of plaque or BOP or the number of caries-affected teeth reduced. On average 1.5 ± 2.5 teeth were lost. Some periodontal risk factors increased, such as obesity, HbA1c and inflammatory markers; others such as smoking or self-rated oral health improved.

Though PD increased significantly ($p < 0.001$) between baseline and follow-up examination, there was a very small difference of 0.3 mm with wide overlap between them (visualized in Figure S2). As shown there, an increase in mean PD implies

TABLE 1 | Relevant characteristics of the participants at baseline study (SHIP-START-0) compared with those of follow-up (SHIP-START-2), number (percentage), mean ± SD or median (IQR, 25th–75th percentile).

	Baseline (N = 1887)	Follow-up (N = 1887)	p
Age, years	45.6 ± 13.1	56.1 ± 12.9	< 0.001
Age range, years	20–79	31–89	—
Female sex	993 (52.6)	993 (52.6)	1.000
No. of teeth (edentulous excluded)	22.0 ± 5.9	20.5 ± 7.0	< 0.001
Mean PD, mm	2.4 ± 0.6	2.7 ± 0.6	< 0.001
Mean CAL, mm	2.3 ± 1.5	2.9 ± 1.6	< 0.001
Extent PD ≥ 3 mm, %	41 (25–58)	52 (37–69)	< 0.001
Extent PD ≥ 4 mm, %	4.2 (0–12.5)	7.5 (1.8–20.8)	< 0.001
Bleeding on probing, %	29 (13–50)	21 (8–38)	< 0.001
Plaque %	46 (25–71)	15 (0–38)	< 0.001
Caries, decayed sites present (%)	396 (21.0)	319 (16.9)	< 0.001
Body mass index (BMI, kg/m^2)	26.7 ± 4.5	28.1 ± 4.8	< 0.001
Waist-to-height ratio	0.51 ± 0.07	0.54 ± 0.08	< 0.001
HbA1c, %	5.3 ± 0.7	5.5 ± 0.8	< 0.001
Fibrinogen, g/L	2.9 ± 0.6	3.1 ± 0.7	< 0.001
Smoking, current (%)	430 (22.8)	368 (19.5)	0.012
Frequency of dental visits, last year	2.8 ± 2.8	2.6 ± 2.6	0.023
Self-rated oral health as 'poor' (%)	494 (26.2)	385 (20.4)	< 0.001

that fewer shallow pockets but more extreme deep pockets were present. For this reason, we divided the baseline mean PD percentiles into quintiles to follow the PD distribution over time. Distribution of these PD figures across the quintiles is presented in Table 2, along with the age, mean follow-up PD in its own quintiles and number of participants losing teeth between both observations. The initial number of teeth belonging to the different quintiles varied between 24 and 19 throughout the first to the fifth quintile.

Therefore, we followed the baseline PD quintiles to see which of these quintiles the participants will end in follow-up PD quintile into which they were then distributed. This trajectory is shown in Figure 1 for the extreme first and fifth baseline quintiles dispersed into the final follow-up PD quintiles.

The PD trajectories from baseline quintiles to the follow-up distributional quintiles as their destinations revealed that participants, whether they started from the lowest or from the highest baseline quintiles, ended largely in identical or adjacent follow-up quintiles (Figure 1). Only a minority of participants were subject to profound quintile changes to the worse (from the first quintile up) or to the better (from the fifth quintile down).

Besides participants without tooth loss ($N=962$), two categories with tooth loss were observed: one category ($N=553$) was relatively independent of baseline PD in participants who lost 1–2 teeth (except first quintile), and the other was with > 2 teeth lost ($N=372$), exhibiting a strong dose–response relation to PD quintiles (Table 2). Albeit with small differences, baseline PD distribution differentiated between these distinct tooth loss categories across the follow-up time period (Figure 2, left). PD extent, defined as the percentage of sites PD ≥ 3 mm or PD ≥ 4 mm, also exhibited this pattern with similar margins (Figure 2, middle and right panel, respectively). Loss of > 2 teeth over 10 years was clearly seen in a distinct group of participants discernible by their PD distribution.

Although higher PD quintiles were associated with age, quintiles from first to fifth were distributed across the complete span from 20 to 80 years of age. Correspondingly, individual

TABLE 2 | Mean PD (range) in quintiles at baseline and follow-up associated with tooth loss for those who lost 1–2 or > 2 teeth (% of baseline quintiles).

Mean PD in quintiles baseline, *N*	Age, years baseline	Mean PD quintiles follow-up, *N*	Initial no. of teeth	1–2 Teeth lost	≥ 3 Teeth lost
First, 1.7 (1.0–1.9), 378	39.7 ± 13.5	First, 2.0 (1.3–2.2), 378	24.2 ± 4.7	89 (23.5)	20 (5.3)
Second, 2.1 (1.9–2.2), 377	41.7 ± 12.3	Second, 2.3 (2.2–2.4), 388	23.7 ± 4.4	114 (30.2)	31 (8.2)
Third, 2.3 (2.2–2.4), 385	47.0 ± 12.8	Third, 2.6 (2.4–2.7), 373	22.0 ± 5.6	124 (32.2)	60 (15.6)
Fourth, 2.6 (2.4–2.8), 370	48.6 ± 12.7	Fourth, 2.8 (2.7–3.1), 377	21.1 ± 6.3	112 (30.3)	86 (23.2)
Fifth, 3.3 (2.8–5.3), 377	50.9 ± 10.7	Fifth, 3.6 (3.1–6.9), 371	19.1 ± 6.6	114 (30.2)	175 (46.4)

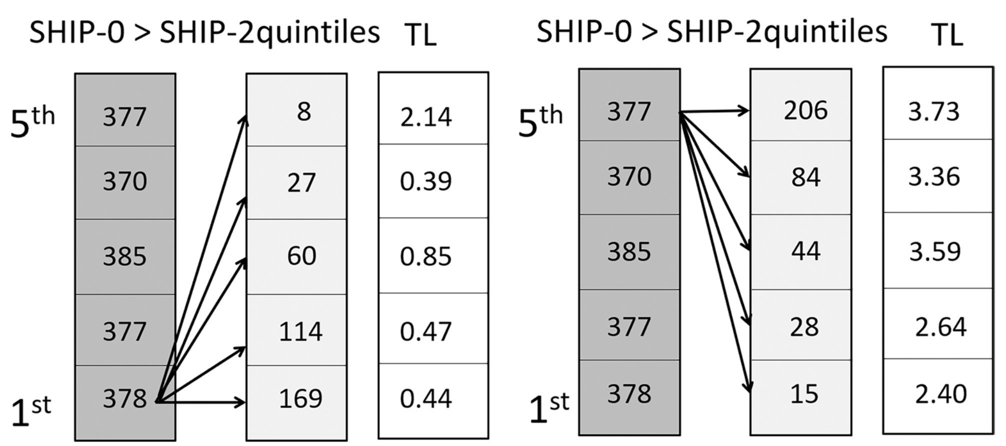

FIGURE 1 | Participants' PD 10-year trajectory within population ($N=1887$). Number of participants within PD quintiles at baseline (dark grey) passing during 10 years into the new follow-up quintiles (light grey) with tooth loss during 10 years (TL). For clarity, merely repartitions from first and fifth start quintiles are shown.

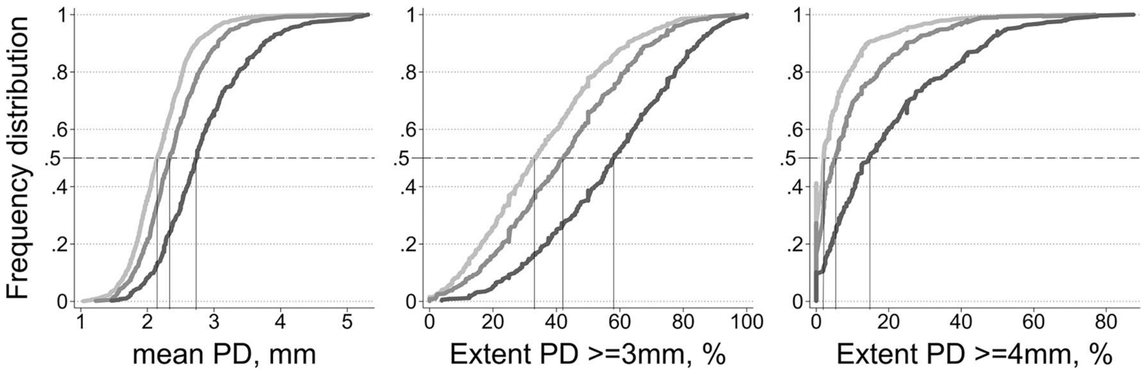

FIGURE 2 | Cumulative frequency distribution of mean PD (left) and PD extent (middle and right) at baseline for three categories of tooth loss as indicated. Half maximum PD indicated at 0.5 were 2.15, 2.35 and 2.74 mm for the respective tooth loss category, half maximum median extent ≥ 3 mm PD 33%, 42% and 58% and ≥ 4 mm PD 2.1%, 5.5% and 15%, respectively. Dotted grid lines represent PD quintile boundaries.

TABLE 3 | Baseline factors associated with mean PD (mm) at baseline (SHIP-START-0) and mean PD at follow-up (SHIP-START-2) as dependent variables (*N* = 1887), ß coefficients and 95% CI.

	PD at baseline	*p*	PD at follow-up	*p*
Age, 10-year intervals	0.05 (0.03–0.07)	< 0.001	0.05 (0.02–0.07)	< 0.001
Female sex (ref. male)	−0.14 (−0.19 to −0.10)	< 0.001	−0.07 (−0.13 to −0.02)	0.010
Extent BOP, 10% increments	0.09 (0.07–0.10)	< 0.001	0.04 (0.03–0.05)	< 0.001
Extent plaque, 10% increments	0.00 (−0.01–0.01)	0.38	0.02 (0.01–0.03)	0.001
Reported mobile teeth	0.30 (0.21–0.39)	< 0.001	0.24 (0.14–0.35)	< 0.001
Mobile dentures present	0.15 (0.09–0.22)	< 0.001	0.13 (0.05–0.20)	0.001
Waist-to-height ratio	0.43 (0.07–0.80)	0.020	0.62 (0.16–1.08)	0.009
HbA1c, %	0.00 (−0.04 to 0.04)	0.98	0.04 (−0.01 to 0.08)	0.096
Fibrinogen, g/L	0.04 (0.00–0.08)	0.042	−0.04 (−0.08 to −0.00)	0.037
Education, > 10th grade	0 (ref.)	—	0 (ref.)	—
10th grade	0.05 (0.00–0.10)	0.037	0.08 (0.02–0.14)	0.006
< 10th grade	0.17 (0.11–0.22)	< 0.001	0.09 (0.00–0.17)	0.043
Smoking, never	0 (ref.)	—	0 (ref.)	—
Quit	0.04 (−0.01 to 0.09)	0.15	0.02 (−0.04 to 0.07)	0.58
Current	0.17 (0.11–0.22)	< 0.001	0.28 (0.21–0.34)	< 0.001
Oral health, very good/good	0 (ref.)	—	0 (ref.)	—
Fair	0.00 (−0.04 to 0.04)	0.96	0.02 (−0.03 to 0.07)	0.40
Poor rated	0.11 (0.04–0.18)	0.003	0.11 (0.02–0.20)	0.017

PD values were wildly scattered across the whole age range (not shown). As the age difference between the PD quintiles was high (11.2 years, Table 2), we repeated this analysis for younger participants (≤ 50 years of age) and the older ones (> 50 years of age). The results are collected in Table S1a,b, together with the corresponding tooth loss. Generally, the results within these age strata correspond to those of the total study group.

Tooth loss follows in line with PD trajectories: largely low when remaining in low quintiles, but high when ending in the upper quintiles (starting with the first). A different pattern was observed in participants who started from the fifth quintile, that is, deep pockets at baseline.

Risk factors at baseline determined the mean PD (Table 3, left side) as well as the different tooth loss categories downstream. Most covariates associated significantly with PD at baseline remained significantly associated with PD assessed 10 years later (regression in Table 3, right). PD extent expressed as the percentage of sites ≥ 4 mm followed the same regression scheme (Table S2).

PD at baseline was significantly associated with tooth loss over the 10-year follow-up period with different impacts on the tooth loss categories. Higher PD quintiles were increasingly associated with tooth loss in a dose-dependent manner, even when adjusted for other reasons of tooth loss such as age, BOP, caries, mobile teeth or smoking (Table 4). The difference in the PD-related incidence rate ratios (IRR) between participants who lost > 2 teeth as compared to those who lost 1–2 teeth was 4.07 (95% CI: 2.57–6.43) for the fifth PD quintile as compared to 1.63 (95% CI: 1.27–2.09) (for % PD ≥ 4 mm quintiles, see Table S3). The corresponding receiver operating characteristic (ROC) curves are depicted in Figure S2. These represent areas under the curve (AUC) of 0.70 (95% CI: 0.67–0.73) and 0.89 (95% CI: 0.87–0.91) for loss of 1–2 or ≥ 3 teeth, respectively.

4 | Discussion

In this population-based study we stratified mean PD figures of all participants into quintiles based on percentage rank distributions, which were established separately at the baseline and follow-up after 10 years. The following observations stood out in particular:

- Distribution of PD across quintiles at baseline was clearly age-dependent and was associated with the number of teeth at baseline and follow-up and, accordingly, with tooth loss during 10 years.
- During the follow-up, participants starting from the different PD quintiles at baseline will turn up again within the initial or adjacent quintiles at follow-up, irrespective of whether it was the lowest or highest.
- Risk factors for increasing PD collected at baseline also significantly affected the follow-up PD outcome (Table 3).
- Irrespective of using PD severity or PD extent at baseline, it clearly differentiated between participants losing no teeth at all, losing 1–2 teeth or > 2 teeth during the follow-up (Figure 2, Table 4).

In patients seeking treatment and suffering from periodontal complaints, their awareness of periodontitis was associated with increased PD and the number of missing teeth (Abdulkareem et al. 2021). Even in maintenance therapy, increasing residual PD is a risk factor for tooth loss (Matuliene et al. 2008). There is good evidence that the goal of active periodontal therapy should be to maintain shallow PD with low BOP associated with the best chance of periodontal health with a low risk of tooth loss (Bertl et al. 2022).

In this study, we only used PD for prognosis.

TABLE 4 | Association between tooth loss and baseline risk factors including the mean PD in quintiles.

Baseline independents[a]	1–2 Teeth lost	*p*	≥ 3 Teeth lost	*p*
Mean PD quintiles				
First	0 (ref.)	—	0 (ref.)	—
Second	1.24 (0.99–1.57)	0.065	1.52 (0.92–2.53)	0.10
Third	1.29 (1.03–1.63)	0.029	2.20 (1.38–3.50)	0.001
Fourth	1.29 (1.02–1.63)	0.035	2.97 (1.88–4.68)	< 0.001
Fifth	1.63 (1.27–2.09)	< 0.001	4.07 (2.57–6.43)	< 0.001
Age, years	1.02 (1.01–1.03)	< 0.001	1.04 (1.03–1.05)	< 0.001
Female sex (ref. male)	1.03 (0.89–1.18)	0.73	1.12 (0.96–1.32)	0.15
Extent BOP, 10% steps	1.00 (0.98–1.03)	0.84	1.04 (1.01–1.07)	0.015
Decayed caries sites present	1.20 (1.03–1.40)	0.022	1.31 (1.12–1.53)	0.001
Dental visits per year	1.02 (1.00–1.04)	0.031	1.03 (1.01–1.05)	0.015
Reported mobile teeth (yes/no)	1.52 (1.26–1.84)	< 0.001	1.63 (1.39–1.90)	< 0.001
Smoking, never	0 (ref.)	—	0 (ref.)	—
Quit	1.11 (0.95–1.30)	0.20	1.19 (0.97–1.44)	0.09
Current	1.12 (0.94–1.34)	0.19	1.50 (1.23–1.83)	< 0.001
Oral health, very good/good	0 (ref.)	—	0 (ref.)	—
Fair	1.26 (1.09–1.45)	0.002	1.41 (1.16–1.71)	< 0.001
Poor rated	1.39 (1.15–1.68)	0.001	1.97 (1.60–2.41)	< 0.001

Note: Dependent—tooth loss categorized as 1–2 teeth lost (N = 553) or ≥ 3 teeth lost (N = 372) versus zero loss (N = 962), IRR with 95% confidence intervals.
Abbreviation: IRR, incidence rate ratio.
[a]HbA1c, WHtR, fibrinogen and education, all without significance additionally included.

Though the CAL variance is larger than PD variance, the inherent variation in PD seems to reflect the impact of the underlying biological and socioeconomic driving forces for the progression of periodontitis. According to their PD rank, most of the subjects found themselves back to the same or a neighbouring rank after 10 years (Figure 1). This observation supports our assumption that PD reflects the concurrence of different risk factors and that their impact does not change over time (Table 3). This invariability gives this method great robustness, explaining that tooth loss over 10 years is strongly associated with baseline PD ranking. Usually, in longitudinal studies PD means were compared before and after the scheduled time (e.g., Preshaw and Heasman 2005; Herz et al. 2024). Instead, we focused on participants' percentile rank split into quintiles within the population to follow the PD trajectory and tooth loss. Although the increase in mean PD (ranging between 0.2 and 0.3 mm) was independent of quintile membership, tooth loss increased in the higher quintiles (Figure 1, Table 2).

A recent review identified 5 periodontal risk assessment tools, which were investigated in 19 studies (Lang, Suvan, and Tonetti 2015). Besides PD, the prognostic tools included tooth loss, BOP, bone loss or bone loss in relation to age; none included solely PD as sign of periodontitis. Our approach can be compared to the Page et al. (2003) study with 523 participants and a 12-year follow-up. They reported that their calculated 5-point risk scale including PD and alveolar bone loss after 15 years was associated with increased numbers of teeth lost, comparable to the tooth loss associated with the PD quintiles reported here (Figure 1, Table 2).

SHIP is an epidemiological study comprising periodontally treated and untreated participants. Nevertheless, subjects reporting to be treated for periodontal disease did not differ from their untreated counterparts in that treatment did not result in fewer tooth loss than without treatment. In previous studies we have shown that the SHIP data reflect the everyday practice of an East German general dentist (Schwahn et al. 2004; Samietz et al. 2015). In most healthcare settings, the majority of periodontal treatments are performed by general dentists and not by specialists. As a result, residual pockets are the final outcome that patients have to live with to varying degrees, depending on the skill and diligence of the treating dentist. The problem of inadequate treatment seems to be very widespread. Even in academic settings, scaling results vary widely between groups (Joseph et al. 2023).

Tooth loss due to periodontitis is assumed to account for 30%–35% of the total (Martinez-Canut 2015; Petsos et al. 2020), whereas other factors such as trauma, caries, endodontic problems, root fractures and elective extractions contribute to approximately 35%–37% (Al-Shammari et al. 2005). Mostly, tooth loss was reported as the average number of teeth lost, often as teeth lost/patient/year (Petsos et al. 2020; Hassel et al. 2018). In this population study, 962 (51%) participants lost no tooth, 553 lost 1–2 teeth (29%) and 372 (20%) lost > 2 teeth. Considerable differences were observed between these tooth loss groups with respect to the influence of PD (Table 4). The strong relationship with PD quintiles corresponds to the conclusion made by Loos and Needleman (2020) that a low proportion of higher PD is associated with periodontal stability and diminished tooth loss in the long run.

Tooth loss figures in the range of 0.01–0.36 were reported in maintenance patients, often with itemization according to risk factors (Helal et al. 2019). In our population, the tooth loss figures were 0.16, 0.14 and 0.58 for the overall sample, the 1–2 loss category and the ≥ 3 loss category, respectively. This indicates different tooth loss patterns depending on the periodontal status. Across all quintiles, participants in the 1–2 tooth loss category have smaller PD than their counterparts in the ≥ 3 tooth loss category. Whereas caries impact was hardly different between these tooth loss categories, smoking was a risk, especially for the ≥ 3 tooth loss category (Table 4). Age as a major risk factor shifts periodontal case definitions coming from frequency distributions (i.e., percentile charts) rather than from direct periodontal measures characteristically (Meisel and Kocher 2009). Regardless of all such risks, in general practice questionable and hopeless teeth are usually extracted in diseased patients in order to allow for a comprehensive prosthetic rehabilitation plan.

Considering the primary goal in the dental practice, which is preservation of natural teeth, and that the initial diagnosis is made by PD and BOP, practitioners should be aware of the long-term PD trajectory on tooth loss. To reach and maintain periodontal stability during supportive periodontal treatment (SPT), individual quantitative data from comprehensive residual PD profiles may contribute to the improved planning of SPT intervals (Ramseier et al. 2019).

Recently, in a follow-up of 9–16 years, a site-specific approach to prevent from PD worsening in individuals was recommended during supportive periodontal care (Herz et al. 2024). In order to prevent ongoing periodontal disease, monitoring of residual PD after therapy is expedient and indicated to avoid progression and tooth loss (Matuliene et al. 2008). Percent PD extent check-ups are useful to work out the risk of disease progression and the advisable interval between recall visits (Ramseier et al. 2019). Thus, reduced PD and recovery of BOP sites were proposed as the endpoints of periodontal therapy (Loos and Needleman 2020). To compare with our follow-up time, this is also true after 10 years of SPT (De Wet, Slot, and Van der Weijden 2018).

5 | Conclusion

The capture of PD in the dental practice as a predictive measure for periodontal disease progression and prospective tooth loss offers advantages of being quick and easy to perform. Plain communication of their PD position relative to the practice population could give patients motivation to seek treatment to prevent periodontitis-related tooth loss. Our data analysis raises the question whether PD data may suffice for developing prognosis tools. The drawback of the percentile approach is that it only provides population-related thresholds, which cannot be generalized. Since most offices use digital charts, the collection of practice-specific data should be possible to establish specific benchmarks. Similar analyses should be performed comparing different practice data to find out whether PD ranking is robust to select patients at high risk for tooth loss.

Author Contributions

P.M. and T.K. contributed to the design and the conception of the study. H.V. contributed to the data collection and interpretation of the data. All authors contributed to the final draft of the paper and approved the same.

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Ethics Statement

All participants gave their written informed consent and the study was approved by the ethics committee of Greifswald University. The study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data from SHIP are available after data application and signature of a data transfer agreement. The data dictionary and the online application form are available at: https://transfer.ship-med.uni-greifswald.de/FAIRequest/ Involving a local collaborative partner to facilitate the application process is recommended.

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