Periodontal health and patient reported outcomes

Sharma, Praveen; Kristunas, Caroline; Chapple, Iain; Dietrich, Thomas

DOI:
10.1111/jcpe.13776

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Sharma, P, Kristunas, C, Chapple, I & Dietrich, T 2023, 'Periodontal health and patient reported outcomes: A longitudinal analysis of data from non-specialist practice settings', *Journal of Clinical Periodontology*, vol. 50, no. 5, 13776, pp. 582-590. https://doi.org/10.1111/jcpe.13776

Received: 18 August 2022 | Revised: 4 January 2023 | Accepted: 10 January 2023

DOI: 10.1111/jcpe.13776

ORIGINAL ARTICLE

Journal of Clinical Periodontology WILEY

Periodontal health and patient-reported outcomes: A longitudinal analysis of data from non-specialist practice settings

Praveen Sharma | Caroline Kristunas | Iain L. Chapple | Thomas Dietrich

Periodontal Research Group, School of Dentistry, College of Medical and Dental Sciences, University of Birmingham, Birmingham, UK

Correspondence
Praveen Sharma, School of Dentistry, University of Birmingham, Birmingham, UK.
Email: praveen.sharma@nhs.net

Abstract

Aim: To explore the associations between periodontal health and patient-reported outcomes (PROs), accounting for changes over time, in a large, non-specialist dental practice patient cohort.

Materials and Methods: This longitudinal study used data from 13,162 dentate patients, collected by 162 dentists at routine appointments between May 2013 and April 2020, in 238 non-specialist dental practices across the United Kingdom. Dentists collected data, as part of routine clinical care, on periodontal probing pocket depths, alveolar bone loss, bleeding on probing, as well as a range of covariates. Patients inputted data on outcomes (oral pain/discomfort, dietary restrictions, and dental appearance). Mixed-effects logistic regression analysis was used to investigate the associations between periodontal health and PROs. Models accounted for clustering at the patient and dentist level and were adjusted for time and variables which were thought to confound these associations.

Results: The odds of all PROs tended to increase with worsening periodontal parameters. For example, the odds of reporting pain in the worst periodontal health category were 1.99 (95% confidence interval: 1.57–2.53) times higher than in the best periodontal health category.

Conclusions: This study confirms, using a large longitudinal dataset from a unique non-specialist setting, the associations between poorer periodontal health and poorer PROs.

KEYWORDS
dental practice, patient reported outcomes, periodontitis

Clinical Relevance

Scientific rationale for study: Most studies investigating the relationship between periodontal health and patient-reported outcomes (PROs) have been conducted in a hospital or a specialist-practice setting, which is not where most dental care is delivered. This study provides evidence from a longitudinal study, conducted in over 200 non-specialist dental practices, of the association between periodontal health and three principal PROs.

Principal findings: The odds of patients reporting pain, restrictions in diet, or unhappiness with dental appearance increase with worsening periodontal health.
Practical implications: By highlighting the associations between periodontal health and PROs in a general dental setting, this study lends support to the potential benefit of preventing or treating and managing periodontitis for patients.

1 | INTRODUCTION

There is a growing recognition in the periodontal community of the impact of periodontal disease, and its treatment, on the quality of life and general well-being of patients (Buset et al., 2016; Wong et al., 2021). This has heightened awareness of the need to record patient-reported outcomes (PROs) in clinical research studies as well as embedding PROs as key outcome measures of clinical care, alongside traditional clinical measures of successful periodontal therapy. A systematic review utilizing data from 10 short-term (6 months or less) and three longer-term (more than 6 months) studies suggests that improvement in pain, function, and aesthetics, as reported by patients, are all realistically achievable goals following non-surgical periodontal therapy (Khan et al., 2021). These studies comprised three randomized control trials, nine case series, and one quasi-experimental study. The participant numbers in these studies ranged from 21 to 145. Twelve out of the 13 studies included in this review were conducted in a hospital and/or specialist periodontal practice setting, rather than a non-specialist, family practice-based dental setting. We have previously reported associations between periodontal health and PROs (oral pain, dietary restrictions, and dental appearance) using cross-sectional data from a large, non-specialist dental practice database (Sharma et al., 2016; Sharma et al., 2018). The cross-sectional nature of the data available to us at the time did not allow us to explore the associations between PROs and periodontal health over time.

The aim of the present study was to use the longitudinal data now available to us to explore the associations between clinical and radiographic periodontal parameters and PROs in a non-specialist family dental practice setting.

2 | MATERIALS AND METHODS

2.1 | Patient population

This study used data collected by 162 dentists, as part of routine clinical care, in 238 non-specialist dental practices across the United Kingdom (Figure 1). The appointment dates ranged from May 2013 to April 2020, ending at the start of the first COVID lockdown in the country where dental practices shut for all but emergency care.

The dentists were part of a dental payment plan scheme (Denplan). The requirements of these practices have been described earlier (Sharma et al., 2016; Sharma et al., 2018). Briefly, practices comply with key outcome measures, deemed consistent with "optimal" dental service provision (Busby et al., 2013). Since 2013, dentists have used the Denplan PreViser Patient Assessment (DEPPA) tool to capture data on patients' demographics, risk factors for oral diseases, and clinical and radiographic findings. DEPPA also contains a questionnaire that captures data on patients' perceptions of their oral health and behaviours. It provides personalized risk and disease scores using validated algorithms, in the form of individualized reports to be used by dental care professionals to support patient education and conversations about behaviour change for risk factor control (Asimakopoulou et al., 2015, 2019).

All personal identifiers are anonymized and collected in an encrypted format and the system is used as part of routine clinical care. The UK Data Commissioner has confirmed that the collected data is non-personalized. Ethical review was therefore not required for this analysis. As data were not recorded for research purposes, no formal calibration or no standardization of clinical or radiographic procedures was performed.

2.2 | Periodontal/exposure variables

Following clinical examination, dentists used the DEPPA system to document the deepest periodontal probing depth (PPD) per sextant

FIGURE 1 Geographical distribution of dental practices contributing to data in the analysis [Colour figure can be viewed at wileyonlinelibrary.com]

(<5 mm, 5–7 mm, or >7 mm), any bleeding on probing (BoP) in each sextant (yes/no), and the maximum radiographic alveolar bone loss (ABL) per sextant (<2 mm, 2–4 mm, >4 mm) as measured from the cemento-enamel junction to the alveolar crest, from available radiographs. Third molars were excluded from the periodontal assessment. This information was used to classify eight periodontal health states as previously reported (Sharma et al., 2018) (Table 1).

2.3 | PRO variables

Patients self-reported the outcomes on a 3-point Likert scale using questions on pain ("Are you experiencing any pain or discomfort in your mouth?" [Yes/Some/No]), dietary restriction ("Do your teeth allow you to eat an unrestricted diet?" [Yes/Mainly/No]), and appearance ("How do you feel about the appearance of your teeth?" [Happy/Some concerns/Unhappy]).

2.4 | Other data

The DEPPA system collects data on a range of variables entered by both the dentist and the patient. These included patients' self-reported age in years, sex (male/female), smoking status (ever/never smoker), diabetes status (yes/no), tooth grinding habits (yes/no), and frequency of sugar intake (less than four times/four or more times in a typical day). Data on the number of teeth with restorations and the number of teeth needing restorations, patient's oral hygiene (adequate/inadequate), patient's dental attendance not as regularly as advised by the dentist (yes/no), presence of cervical tooth wear as a measure of abrasion (yes/no), and salivary flow (adequate/inadequate) were collected, as judged by the clinician.

2.5 | Length of follow-up

The median follow-up time was 2.2 years (IQR: 2.0, 2.6) (range: 0.5–6.4). The number of visits per patient varied, with 79.2% of patients having a maximum of two visits, 13% having a maximum of three visits, and 7.8% had four or more visits.

2.6 | Statistical analysis

The following statistical analysis plan was defined a priori. Directed acyclic graphs specifying causal hypotheses were constructed to inform which variables were used in multivariable models to evaluate the association between periodontal state and PROs. To avoid sparse strata and facilitate interpretability, binary PRO variables were generated for pain (yes/some vs. no), dietary restriction (yes vs. mainly/no), and appearance (happy vs. some concerns/unhappy). In addition, we created binary outcome variables based on the number of positive PRO responses (at least one vs. none; and more than one vs. one or none).

The cohort was described at baseline (Table 1) and at the last recorded visit (Table 2).

Mixed-effects logistic regression analysis was used to investigate the associations between each PRO as the outcome variable and the various categories of periodontal parameters as independent variables. Models accounting for clustering at the patient and dentist level (random effects) were adjusted for time (visit number) and variables which were thought to confound these associations (fixed effects). These variables included age, sex, smoking and diabetes status, number of teeth present, number of teeth with restorations, number of teeth needing restorations, oral hygiene, dental attendance, abrasion, grinding habits, salivary flow, and frequency of sugar intake. If covariates were not statistically significant in the model, they were removed and the two models, with and without the covariates omitted, were compared using likelihood ratio tests to see if the model fit was better with or without the omission of those covariates. Models with the best fit were used in the analyses.

The adjusted odds ratios and two-sided 95% confidence intervals (CIs) for reporting various outcomes were calculated by periodontal state, with previous and current healthy state as the base category.

Patients with missing data for any covariates or those with less than 6 months of total follow-up were not included in the analysis.

Two sensitivity analyses were conducted: first, using models unadjusted for confounders, but still accounting for clustering at the patient and dentist level; and second, by excluding observations from visits that were within 3 months of the previous visit, as it was felt that this timeframe was too short for any periodontal advice/intervention to impact on PROs.

3 | RESULTS

3.1 | Sample characteristics

The final analytical sample consisted of 13,162 dentate patients, following the exclusion of 197 patients (1.5%) with missing data out of the 13,359 patients with at least two visits recorded. Missing data was primarily due to missing periodontal health state at baseline, missing for 190 patients. At the first visit, the mean age of patients was 55 years (SD 15.4, range 16–98), 57% were male, 5.1% reported being diagnosed with diabetes, and 63% were never smokers. The mean number of teeth present, not including wisdom teeth, was 25 (SD 3.9, range 1–28). Of these, a mean of 11 (SD 5.7, range 0–28) were restored and 0 (IQR: 0, 0, range 0–20) needed restorations. Only 21 patients, contributing a total of 0.11% of visits, had 5 or fewer teeth. Five percent did not attend the dentist as regularly as recommended, 48.8% had inadequate oral hygiene, and 11% reported a high frequency of sugar intake (Table 1).

With regard to their periodontal parameters, 2693 (18.5%) were in the healthiest group, 3081 (21.2%) had BoP with no or limited periodontal tissue loss, and the remainder exhibited various levels of periodontal tissue loss evidenced by PPD 5+ mm and/or ABL 2+ mm with or without BoP (Table 1). The demographics of the cohort at the last recorded visit is included (Table 2).

TABLE 1 Baseline demographics of the cohort by periodontal health state (missing = 7)

	Whole cohort ($n = 13,352$)	Cohort categorized by periodontal health state							
		I ($n = 1688$)	II ($n = 3459$)	III ($n = 1592$)	IV ($n = 3098$)	V ($n = 1283$)	VI ($n = 867$)	VII ($n = 825$)	VIII ($n = 540$)
Age (years) (missing = 34)	54.8 (15.4)	47.0 (16.1)	45.7 (15.9)	60.7 (11.5)	58.8 (12.3)	57.0 (12.9)	65.7 (10.7)	63.4 (10.7)	61.6 (10.8)
Male (%)	56.5	59.4	57.1	58.6	58.3	50.6	54.7	53.7	48.7
Diabetic (%) (missing = 41)	5.1	2.5	3.2	6.0	6.1	5.1	9.9	7.2	7.1
Never smoker (%) (missing = 415)	63.3	73.9	70.4	66.1	62.6	56.2	51.6	43.2	46.4
Teeth present (not including wisdom teeth)	25.0 (3.9)	26.2 (3.3)	26.1 (3.0)	24.7 (4.0)	25.0 (3.4)	24.9 (3.8)	22.7 (4.9)	22.7 (4.8)	22.9 (4.9)
Restored teeth	11.1 (5.7)	9.1 (6.0)	9.0 (5.9)	12.8 (5.1)	12.6 (5.1)	12.0 (5.2)	12.2 (4.9)	11.8 (5.1)	11.5 (5.3)
Teeth needing restoration	0.32 (0.89)	0.22 (0.71)	0.34 (0.95)	0.26 (0.71)	0.34 (0.92)	0.41 (0.99)	0.28 (0.78)	0.40 (0.98)	0.33 (0.97)
Frequency of dental visits less than recommended (%)[a]	4.7	2.1	5.4	1.9	5.9	5.2	3.7	6.9	6.9
Improvement in oral hygiene needed (%)	48.8	20.0	60.5	28.1	55.4	53.0	52.4	55.4	62.4
High frequency of sugar intake (%)	11.1	9.6	14.6	7.7	10.1	11.4	9.6	10.4	12.0
Patient-reported outcomes (%)									
Pain	14.3	13.0	13.6	14.0	13.8	16.1	14.0	14.8	22.2
Diet restrictions	9.1	7.3	6.4	9.7	9.0	9.0	12.3	14.7	18.0
Unhappiness with appearance	25.0	22.5	23.0	25.6	24.4	26.3	27.2	32.7	29.3
Any patient-reported concerns	37.5	34.2	33.9	38.9	36.8	39.7	40.1	45.6	48.2
More than one patient-reported concerns	9.4	7.5	7.8	9.2	9.0	10.1	11.3	14.3	17.0

Note: I (PPD < 5 mm, ABL < 2 mm, BoP −); II (PPD < 5 mm, ABL < 2 mm, BoP +); III (PPD < 5 mm, ABL 2–4 mm, BoP −); IV (PPD < 5 mm, ABL 2–4 mm, BoP +); V (PPD 5–7 mm, ABL 2–4 mm, BoP ±); VI (PPD < 5 mm, ABL > 4 mm, BoP ±); VII (PPD 5–7 mm, ABL > 4 mm, BoP ±); VIII (PPD > 7 mm; ABL > 4 mm, BoP ±). Data are unadjusted and expressed as mean (SD) unless otherwise stated.

Abbreviations: ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth.

[a]Recommended frequency of dental visits was assessed on a case-by-case basis.

TABLE 2 Demographics of the cohort at last recorded visit by periodontal health state (missing = 5)

		Cohort categorized by periodontal health state							
	Whole cohort (*n* = 13,354)	**I (*n* = 1795)**	**II (*n* = 3492)**	**III (*n* = 1624)**	**IV (*n* = 3074)**	**V (*n* = 1149)**	**VI (*n* = 967)**	**VII (*n* = 744)**	**VIII (*n* = 509)**
Age (years) (missing = 2)	57.6 (15.3)	50.2 (16.1)	49.0 (16.0)	63.0 (11.7)	61.3 (12.6)	60.3 (13.1)	67.8 (10.4)	65.9 (10.5)	64.0 (11.5)
Male (%)	56.5	58.7	57.4	57.9	57.7	52.7	54.8	52.8	48.9
Diabetic (%) (missing = 41)	6.2	3.3	4.1	7.1	7.0	6.6	11.0	9.2	9.6
Never smoker (%) (missing = 416)	61.0	70.8	67.4	63.7	59.5	56.0	48.5	43.4	43.4
Teeth present (not including wisdom teeth)	24.9 (4.0)	26.0 (3.5)	26.2 (3.2)	24.6 (4.0)	24.8 (3.6)	24.5 (4.2)	22.8 (4.6)	22.4 (5.0)	23.0 (5.0)
Restored teeth	11.1 (5.6)	9.4 (5.9)	9.3 (5.8)	12.7 (5.1)	12.4 (5.0)	12.1 (5.2)	12.3 (4.9)	11.6 (5.1)	11.3 (5.3)
Teeth needing restoration	0.24 (0.75)	0.17 (0.55)	0.23 (0.70)	0.22 (0.67)	0.26 (0.71)	0.31 (0.85)	0.26 (0.79)	0.29 (0.98)	0.32 (1.32)
Frequency of dental visits less than recommended (%)[a]	3.9	0.8	3.1	1.9	6.5	9.7	1.7	4.4	3.0
Improvement in oral hygiene needed (%)	49.3	24.4	60.6	26.9	54.6	59.6	50.4	57.0	63.1
High frequency of sugar intake (%)	8.6	7.9	10.1	7.2	8.4	8.7	6.8	9.1	9.4
Patient-reported outcomes (%)									
Pain	12.4	11.3	10.0	13.6	12.6	14.7	12.4	17.2	16.1
Diet restrictions	8.7	7.7	5.1	10.3	7.8	10.8	11.1	17.5	14.9
Unhappiness with appearance	21.9	21.8	18.1	24.1	21.5	21.9	24.8	30.5	24.6
Any patient-reported concerns	33.6	32.6	27.4	38.0	33.6	35.5	36.7	44.8	39.1
More than one patient-reported concerns	8.1	7.2	5.2	8.5	7.3	10.3	10.0	16.4	13.6

Note: I (PPD < 5 mm, ABL < 2 mm, BoP −); II (PPD < 5 mm, ABL < 2 mm, BoP +); III (PPD < 5 mm, ABL 2–4 mm, BoP −); IV (PPD < 5 mm, ABL 2–4 mm, BoP +); V (PPD 5–7 mm, ABL 2–4 mm, BoP ±); VI (PPD < 5 mm, ABL > 4 mm, BoP ±); VII (PPD 5–7 mm, ABL > 4 mm, BoP ±); VIII (PPD > 7 mm; ABL > 4 mm, BoP ±). Data are unadjusted and expressed as mean (SD) unless otherwise stated.

Abbreviations: ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth.

[a]Recommended frequency of dental visits was assessed on a case-by-case basis.

3.2 | Association between periodontal health state and PROs

Overall, the odds of all reported PROs tended to increase with worsening periodontal parameters (Table 3, Figures 2–6). The variances for the random effects in the fitted model are presented in Table S1.

Patients with PPD < 5 had similar odds of reporting pain compared with the base category (periodontal health as defined by PPD < 5 mm, ABL < 2 mm, and no BoP) regardless of whether they had ABL or BoP, whereas patients with PPD > 5 had significantly higher odds of reporting pain, regardless of ABL (Table 3, Figure 2). Similarly, regarding reporting a restriction in diet, patients with ABL in excess of 4 mm had greater odds of reporting restriction in diet compared with patients with ABL < 4 mm, regardless of PPD (Table 3, Figure 3). Individuals with PPD in excess of 5 mm or ABL in excess of 4 mm had increased odds of reporting an unhappiness with their appearance, compared with individuals without (Table 3, Figure 4). Finally, the odds of reporting any of the above concerns or reporting more than one concern increased with worsening periodontal health states compared with the base category of periodontal health (Table 3, Figures 5 and 6).

3.3 | Change in PROs over time

All PRO components reduced over time. The odds of patients reporting pain, restrictions in diet, or unhappiness with their dental appearance reduced by between 4% and 17% with each visit (Table S2). The odds of patients reporting any concerns reduced by 14% (95% CI: 11%–18%) with each visit and the odds of reporting more than one concern reduced by 9% (95% CI: 3%–15%) with each visit.

3.4 | Results from sensitivity analysis

Sensitivity analyses conducted using models unadjusted for confounders gave similar results to the adjusted analyses (Table 3). Sensitivity analyses were conducted removing some observations ($n = 27$) of less than 3 months. The results of the sensitivity analysis were virtually identical to those of the primary analysis (Table S3).

4 | DISCUSSION

In the present longitudinal study of a large, general, family dental practice-based population, we found a dose-dependent relationship between worsening periodontal health state and the odds of reporting pain, restrictions in diet, or unhappiness with dental appearance.

The large sample studied here allows for some meaningful and interesting comparisons between categories of different periodontal health states. The health states were categorized according to the presence or absence of BOP, thresholds of PPD, and ABL. Based on

TABLE 3 Unadjusted and adjusted odds ratios (and 95% confidence interval [CI]) of reporting various outcomes by periodontal health state

	Periodontal health state							
OR (95% CI) of reporting	I	II	III	IV	V	VI	VII	VIII
Pain[a]	1.00	0.93 (0.79–1.09)	0.93 (0.78–1.11)	1.00 (0.86–1.18)	1.20 (0.99–1.44)	0.90 (0.73–1.12)	1.18 (0.96–1.46)	1.77 (1.41–2.22)
	1.00	0.92 (0.78–1.08)	1.00 (0.83–1.20)	1.06 (0.89–1.25)	1.25 (1.02–1.52)	1.02 (0.81–1.28)	1.25 (1.00–1.57)	1.97 (1.55–2.50)
Restricted diet[a]	1.00	0.87 (0.69–1.10)	1.28 (1.01–1.63)	1.28 (1.02–1.61)	1.50 (1.15–1.95)	2.04 (1.55–2.70)	3.08 (2.34–4.06)	4.49 (3.30–6.12)
	1.00	0.89 (0.70–1.12)	1.16 (0.90–1.49)	1.16 (0.91–1.47)	1.30 (0.99–1.72)	1.55 (1.15–2.08)	2.24 (1.67–3.00)	3.57 (2.59–4.92)
Unhappiness with appearance[a]	1.00	1.03 (0.85–1.23)	1.03 (0.84–1.26)	1.14 (0.95–1.38)	1.35 (1.08–1.69)	1.33 (1.04–1.70)	1.94 (1.51–2.50)	1.83 (1.37–2.44)
	1.00	1.01 (0.84–1.22)	1.12 (0.90–1.39)	1.19 (0.97–1.45)	1.35 (1.07–1.72)	1.63 (1.25–2.12)	2.20 (1.68–2.89)	2.07 (1.52–2.82)
Any concerns[a]	1.00	0.99 (0.86–1.14)	1.03 (0.88–1.20)	1.14 (0.99–1.32)	1.34 (1.13–1.59)	1.19 (0.98–1.43)	1.70 (1.40–2.07)	2.17 (1.74–2.70)
	1.00	0.98 (0.85–1.14)	1.07 (0.91–1.25)	1.16 (0.99–1.34)	1.33 (1.11–1.59)	1.31 (1.07–1.60)	1.73 (1.41–2.13)	2.32 (1.85–2.13)
More than one concern[a]	1.00	0.90 (0.72–1.13)	1.07 (0.84–1.36)	1.12 (0.90–1.41)	1.42 (1.09–1.83)	1.65 (1.25–2.17)	2.50 (1.91–3.28)	3.53 (2.60–4.79)
	1.00	0.90 (0.72–1.14)	1.18 (0.92–1.52)	1.19 (0.94–1.51)	1.43 (1.09–1.88)	1.78 (1.33–2.39)	2.54 (1.90–3.40)	3.76 (2.72–5.19)

Note: I (PPD < 5 mm, ABL < 2 mm, BoP −); II (PPD < 5 mm, ABL < 2 mm, BoP +); III (PPD < 5 mm, ABL 2–4 mm, BoP −); IV (PPD < 5 mm, ABL 2–4 mm, BoP +); V (PPD 5–7 mm, ABL 2–4 mm, BoP ±); VI (PPD < 5 mm, ABL > 4 mm, BoP ±); VII (PPD 5–7 mm, ABL > 4 mm, BoP ±); VIII (PPD > 7 mm; ABL > 4 mm, BoP ±).

Abbreviations: ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth.

[a]Adjusted for visit number, age, gender, teeth present, teeth with restoration, dentist frequency, abrasion, teeth grinding, oral health improvement needed, restoration needed, smoking, diabetes, salivation, sugar frequency.

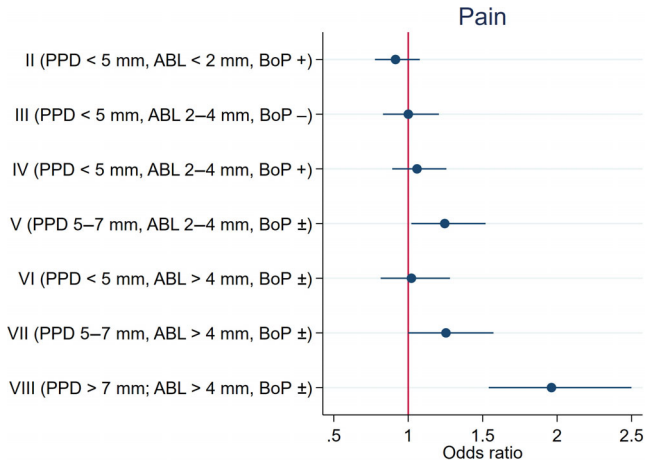

FIGURE 2 Adjusted odds (95% confidence interval) of reporting oral pain by periodontal health state compared to periodontal state of I (PPD < 5 mm, ABL < 2 mm, BoP −). ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth [Colour figure can be viewed at wileyonlinelibrary.com]

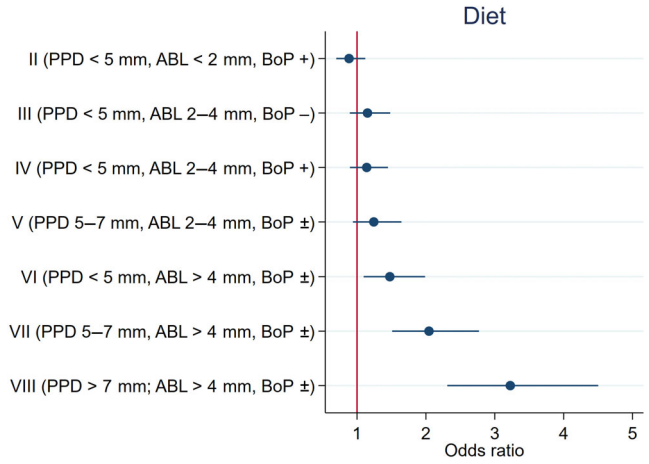

FIGURE 3 Adjusted odds (95% confidence interval) of reporting restricted diet by periodontal health state compared to periodontal state of I (PPD < 5 mm, ABL < 2 mm, BoP −). ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth [Colour figure can be viewed at wileyonlinelibrary.com]

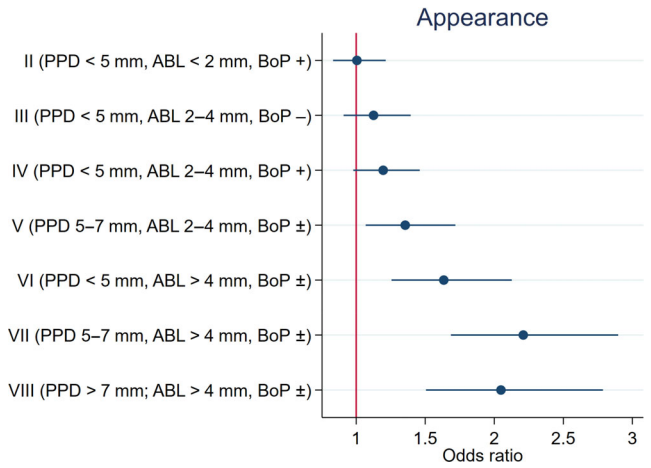

FIGURE 4 Adjusted odds (95% confidence interval) of reporting unhappiness with appearance by periodontal health state compared to periodontal state of I (PPD < 5 mm, ABL < 2 mm, BoP −). ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth [Colour figure can be viewed at wileyonlinelibrary.com]

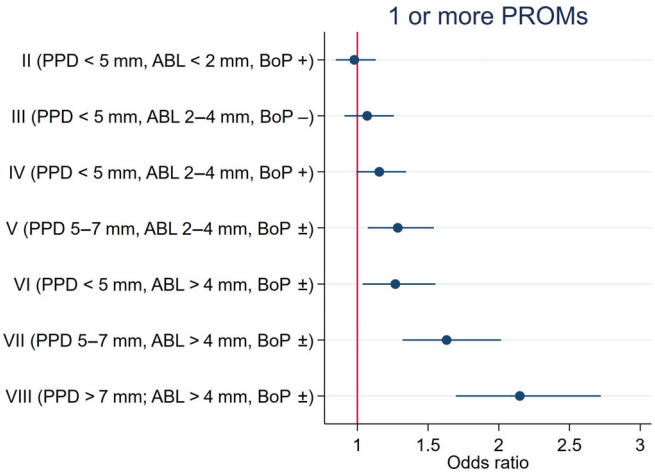

FIGURE 5 Adjusted odds (95% confidence interval) of reporting oral pain or restricted diet or unhappiness with appearance by periodontal health state compared to periodontal state of I (PPD < 5 mm, ABL < 2 mm, BoP −). ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth [Colour figure can be viewed at wileyonlinelibrary.com]

these, the health states can be thought of as being indicative of "current" periodontal disease (with PPD > 5 mm) and/or "previous" periodontal disease experience (with ABL > 2 mm). It is true that ABL may be due to other non-periodontal-disease-related causes. The absence of deep periodontal pockets in the presence of ABL is consistent with the periodontal parameters one would expect to see following successful periodontal therapy, or resolution of active disease. To this end, periodontal health states indicative of previously treated periodontitis exhibited similar odds of reporting pain as health states associated with periodontal health/gingivitis. Health states indicative of previous/current more severe periodontitis (ABL > 4 mm), regardless of their current periodontal health state (in terms of PPD), had increased odds of reporting a restricted diet. This was even after adjusting for number of teeth present. This was also the case with reporting unhappiness with appearance. Hence, the results remain consistent with our previous study (Sharma et al., 2016, 2018) in demonstrating the potential beneficial effect of preventing periodontal diseases and maintaining periodontal health, successful periodontal therapy, and supportive periodontal therapy, or maintenance of periodontal health on the PROs of pain, restricted diet, and unhappiness with appearance.

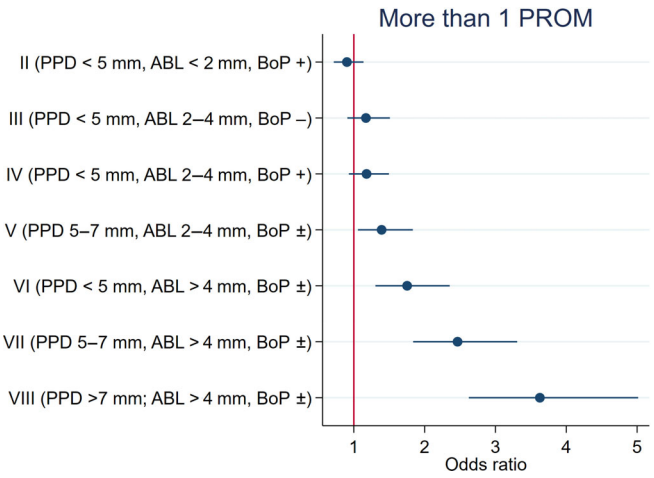

FIGURE 6 Adjusted odds (95% confidence interval) of reporting more than one of oral pain or restricted diet or unhappiness with appearance by periodontal health state compared to periodontal state of I (PPD < 5 mm, ABL < 2 mm, BoP −). ABL, alveolar bone loss; BoP, bleeding on probing either present (+) or absent (−); PPD, periodontal probing depth [Colour figure can be viewed at wileyonlinelibrary.com]

Our study has several strengths. The longitudinal nature of the data with the length of follow-up and multiple dental visits allowed for the clustering of observations within patients and the clustering of patients within dentists, leading to more robust estimates of the associations between PROs and periodontal health state. Despite the limited number of repeated observations on the cohort, changes in PROs were modelled over time, showing improvements in all PROs between visits. The large sample size, collected by non-specialist family dentists, also greatly improves the external validity of the findings, as most dental care is delivered by non-specialist dentists and the data is collected from a wide area of the United Kingdom (Figure 1). The large sample also allowed for adjustment of potential confounders of the relationship between periodontal health state and PROs.

There are also several limitations to our study to be considered, some of which stem from the pragmatic nature of the study and data collected. As data in this study is not collected for research purposes, but rather as part of routine clinical care, there is no examiner calibration, and the data is subject to errors and misclassification. For example, data on "unhappiness with appearance" does not uniquely cover "unhappiness with *gingival* appearance". A carefully controlled and designed clinical study would be able to tease this out given the ability for more bespoke and detailed data collection. Furthermore, we do not have data on what periodontal or other treatments, if any, patients had received during follow-up. It is expected that treatment was undertaken according to standard protocols for non-surgical periodontal care provision, in line with expectations of the regulator for dental care provision in the United Kingdom, namely The General Dental Council. As with our previous study, this dataset derives from practices using a dental payment capitation scheme, which limits the generalizability to within the U.K. healthcare system. The affluent nature of this cohort is illustrated by the relatively stable nature of the dentition with low prevalence of smoking, few teeth needing restorations, and generally good compliance with recall appointments. Finally, as with any study employing observational data, there is the risk of bias due to unmeasured and residual confounding, which may affect the associations seen here. For example, although major causes of pain other than periodontal status (age, gender, numbers of teeth present, numbers of restored teeth and numbers of teeth needing restoration/s, sugar frequency, adherence to recall visits, and improvements in oral hygiene needed/not) were controled for, unmeasured/unknown confounders or residual confounders may have affected our estimates.

With the increasing recognition of the importance of PROs in periodontal clinical practice and research, these outcomes are reported more and more in clinical trials, with calls for PROs to be part of the core outcome sets in periodontal trials (McGuire et al., 2014; Lamont et al., 2021). This increase in the reporting of PROs has led to several systematic reviews in this area, with a recent umbrella review that aimed at summarizing systematic reviews and meta-analyses investigating the impact of periodontitis and its therapy on quality of life (Wong et al., 2021). The latter study found that individuals with periodontitis had worse quality of life compared with periodontally healthy individuals. It also reported that periodontal therapy can improve oral-health-related quality of life of patients with periodontitis. Wong et al. (2021) included eight systematic reviews/meta-analyses published between 2006 and 2020. Of these, the systematic review with the most studies included was by Buset et al. (2016), and of the 37 studies included, 36 were conducted in a hospital or specialist practice settings, limiting generalizability. In future, more studies conducted in a non-specialist setting are hoped to confirm the findings of this study. In addition, as the DEPPA database matures, with longer follow-ups, the data can be analysed to look for longer term associations between periodontal health and PROs.

5 | CONCLUSION

In conclusion, and within the limitations of a pragmatic study conducted using longitudinal data from a large non-specialist family dental practice population, our data demonstrate that poorer periodontal health, as defined by PD > 5 mm and/or ABL > 2 mm and presence BoP, is associated with poorer PROs. This lends further credence to the contention that prevention and successful management of periodontitis improves PROs.

ACKNOWLEDGEMENT

The authors would like to thank the patients and dentists contributing to the DEPPA database.

FUNDING INFORMATION

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

Professor Iain Chapple acts as an advisor to Oral Health Innovations, the licence holder for DEPPA in the UK and Ireland. The other authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ORCID

Praveen Sharma https://orcid.org/0000-0001-6435-4842
Caroline Kristunas https://orcid.org/0000-0001-8945-4671
Iain L. Chapple https://orcid.org/0000-0003-2697-7082
Thomas Dietrich https://orcid.org/0000-0002-2557-7645

REFERENCES

Asimakopoulou, K., Newton, J. T., Daly, B., Kutzer, Y., & Ide, M. (2015). The effects of providing periodontal disease risk information on psychological outcomes - a randomized controlled trial. *Journal of Clinical Periodontology*, *42*(4), 350–355. https://doi.org/10.1111/jcpe.12377

Asimakopoulou, K., Nolan, M., McCarthy, C., & Newton, J. T. (2019). The effect of risk communication on periodontal treatment outcomes: A randomized controlled trial. *Journal of Periodontology*, *90*(9), 948–956. https://doi.org/10.1002/jper.18-0385

Busby, M., Chapple, E., Matthews, R., & Chapple, I. L. C. (2013). Practitioner evaluation of a novel online integrated oral health and risk assessment tool: A practice pilot. *British Dental Journal*, *215*(3), 115–120. https://doi.org/10.1038/sj.bdj.2013.738

Buset, S. L., Walter, C., Friedmann, A., Weiger, R., Borgnakke, W. S., & Zitzmann, N. U. (2016). Are periodontal diseases really silent? A systematic review of their effect on quality of life. *Journal of Clinical Periodontology*, *43*(4), 333–344. https://doi.org/10.1111/jcpe.12517

Khan, S., Khalid, T., Bettiol, S., & Crocombe, L. A. (2021). Non-surgical periodontal therapy effectively improves patient-reported outcomes: A systematic review. *International Journal of Dental Hygiene*, *19*(1), 18–28. https://doi.org/10.1111/idh.12450

Lamont, T. J., Clarkson, J. E., Ricketts, D. N. J., Heasman, P. A., Ramsay, C. R., & Gillies, K. (2021). Developing a core outcome set for periodontal trials. *PLoS One*, *16*(7), e0254123. https://doi.org/10.1371/journal.pone.0254123

McGuire, M. K., Scheyer, E. T., & Gwaltney, C. (2014). Incorporating patient-reported outcomes in periodontal clinical trials. *Journal of Periodontology*, *85*(10), 1313–1319. https://doi.org/10.1902/jop.2014.130693

Sharma, P., Busby, M., Chapple, L., Matthews, R., & Chapple, I. (2016). The relationship between general health and lifestyle factors and oral health outcomes. *British Dental Journal*, *221*(2), 66–70. https://doi.org/10.1038/sj.bdj.2016.525

Sharma, P., Yonel, Z., Busby, M., Chapple, I. L., & Dietrich, T. (2018). Association between periodontal health status and patient-reported outcomes in patients managed in a non-specialist, general dental practice. *Journal of Clinical Periodontology*, *45*(12), 1440–1447. https://doi.org/10.1111/jcpe.13022

Wong, L. B., Yap, A. U., & Allen, P. F. (2021). Periodontal disease and quality of life: Umbrella review of systematic reviews. *Journal of Periodontal Research*, *56*(1), 1–17. https://doi.org/10.1111/jre.12805

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Sharma, P., Kristunas, C., Chapple, I. L., & Dietrich, T. (2023). Periodontal health and patient-reported outcomes: A longitudinal analysis of data from non-specialist practice settings. *Journal of Clinical Periodontology*, 1–9. https://doi.org/10.1111/jcpe.13776