Received: 28 March 2022 | Revised: 4 August 2022 | Accepted: 29 September 2022

DOI: 10.1111/cdoe.12798

COMMUNITY DENTISTRY AND ORAL EPIDEMIOLOGY WILEY

ORIGINAL ARTICLE

Periodontal disease in people with a history of psychosis: Results from the UK biobank population-based study

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Funding information
UK Research and Innovation

Abstract

Objectives: To test the hypotheses that: (1) Prevalence of periodontal disease would be higher in people with a history of psychosis when compared to the general population and (2) Demographic, life-style related factors and co-morbid medical conditions would predict periodontal disease in people experiencing psychosis.

Methods: The authors performed cross-sectional analysis of baseline data from the UK Biobank study (2007–2010), identifying cases with psychosis using clinical diagnosis, antipsychotic medication, and self-report. Demographic (age, gender, ethnicity, socioeconomic status), lifestyle-related(BMI, blood pressure, smoking and alcohol intake, physical activity) and physical co-morbidities (cancer, cardiovascular, respiratory, inflammatory disease and metabolic conditions) were included as potential risk factors for periodontal disease among people with a history of psychosis using logistic regression analyses. The analysis sample included 502,505 participants.

Results: Risk of periodontal disease was higher in people with psychosis, regardless of how cases were identified. Patients with a clinical diagnosis had the highest proportion of periodontal disease compared to the general population (21.3% vs. 14.8%, prevalence ratio 1.40, 95% CI: 1.26–1.56). Older and female cases were more likely to experience periodontal disease. Lifestyle factors (smoking) and comorbidities (cardiovascular, cancer or respiratory disease) were associated with periodontal disease among people with a history of psychosis.

Conclusions: The findings suggest that periodontal disease is more common in people with a history of psychosis, compared to the general population. Prevention and early diagnosis of periodontal disease should be a priority for oral health promotion programmes, which should also address modifiable risk factors like smoking which also contribute to co-morbid systemic disease.

KEYWORDS
oral health, periodontal disease, psychoses, schizophrenia, UK biobank

1 | INTRODUCTION

Oral health is an important part of general physical well-being, self-esteem and overall quality of life.[1,2] Poor oral health due to dental caries and periodontal disease affect key functions like eating, speaking, and smiling.[2] People with psychotic disorders, such as schizophrenia, may be particularly vulnerable to decayed, missing, and filled teeth[3] and require dental treatment,[4] potentially explained by the low uptake of oral health self-care behaviours[5] and side effects from anti-psychotic medication.[6] Indeed, the side effect xerostomia (dry mouth) is associated with reduced salivary flow, which can lead to caries, periodontal disease, glossitis, and stomatitis and predisposes individuals to a greater risk of dental interventions such as restorations and extraction of teeth.[2,7,8] There is a major need to understand and protect the oral health of people experiencing psychosis.

To date, very few studies have explored periodontal disease severity in people with psychotic experiences.[9–12] Periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus.[13] Disease progression leads to loss of periodontal attachment, including bone, and in severe cases may result in tooth mobility and loss tooth.[13] Unlike dental caries which can be restored, periodontal attachment loss is an irreversible process which progresses to tooth loss if left unchecked.[13] The impact of periodontal disease on quality of life is extensive and affects both aesthetics and function which in turn impacts general well-being and self-esteem.[14] Periodontal disease is also a risk factor for systemic disease and abundant literature shows that periodontal disease is associated with systemic diseases like cardiovascular disease and diabetes.[15,16]

There is now considerable evidence that many people in the general population have psychotic experiences that do not lead to a formal psychiatric diagnosis, but can be distressing and disruptive to their lives, and associated with poor physical health outcomes.[17,18] Research in this population could help to ascertain whether psychotic experiences increase the chances of periodontal disease, or whether this is specific to patients with more established disorders and treatment.

The aims of this study were to investigate the extent to which people with a history of psychosis have periodontal disease and whether this is influenced by demographic, lifestyle and co-morbid medical conditions.

The hypotheses were as follows:

1. Prevalence of periodontal disease may be higher and associated with people with a history of psychosis when compared to the general population.
2. Demographic, life-style factors and co-morbid medical conditions would predict periodontal disease in people experiencing psychosis.

2 | METHODS

Identification of people with psychosis has proven inconsistent throughout literature, with some cases defined by clinical diagnosis, while others use self-reported psychotic experiences and/or use of psychotic medication as proxies.[19] To achieve a comprehensive understanding of the periodontal disease disparity among people with a history of psychosis, we identified psychosis patients from UK Biobank cohort study using three independent ways: people with a formal diagnosis of a psychotic disorder, people taking antipsychotic medication, and people living with psychotic experiences in the general population.

The UK Biobank is a good data source with more than 500 000 participants. It includes questionnaires, bio-samples, consented linkage of routinely collected health care data, and provides several indicators that could be used to identify periodontal disease, co-morbid systemic disease and mental disorders.[20]

We performed a cross-sectional analysis of data from the baseline assessments from the UK Biobank study, collected between 2007 and 2010. The age range of UK Biobank participants is between 37 and 73 years at baseline. The description of the full protocol and data collection process for the UK Biobank can be found elsewhere.[20,21]

UK Biobank releases specific datasets to applicants for the purpose of pre-specified research questions, following review and approval from the UK Biobank's Access Sub-Committee. UK Biobank has generic ethical approval from the Northwest Multi-Centre Research Ethics Committee, which covers the UK (NHS Research Ethics Committee Ref 16/NW/0274). This study was approved by the UK Biobank committee and data was released on 19 March 2020 (Application reference number 54633).

2.1 | Participants

The UK Biobank is linked to NHS hospital admission data, enabling access to recorded clinical diagnoses. For the purpose of this study, we used three independent methods for classifying psychosis. In the first method, we identified people with a recorded primary or secondary ICD-10[22] diagnosis of any non-affective psychotic disorder, including psychotic disorder, schizophrenia and schizotypal disorder (ICD-10 code: F20-29), or mood disorders with psychotic symptoms including manic disorder and depressive disorders (ICD10 code: F20-29 plus F302, F312, F315, F323, F333); in the second method, we identified participants taking anti-psychotic medication (see Table S1); and in the third method, we identified participants having psychotic-like experience from mental health questionnaire in the UK Biobank (category 144) by responding positively to any of the four questions asking about their psychotic experience (see Appendix S2).[16] This allowed for examination of periodontal disease outcomes in participants with established psychotic disorders, but also a wider sample of people receiving antipsychotic medication or having psychotic experiences,

which are commonly reported outside of diagnostic groups.[17,18] The comparison sample was all of the UK Biobank participants with none of the above recorded definitions of psychosis.

2.2 | Periodontal disease measure

Self-reported oral health recorded the status of participant's mouth: bleeding gums, dentures, loose teeth, painful gums, toothache, ulcers or none of these. Of those, bleeding gums, painful gums and loose teeth were utilized as surrogates for periodontal disease as they have demonstrated their validity in the absence of a clinical diagnosis.[23,24] Painful and bleeding gums without loose teeth, are associated with mild to moderate periodontal disease, while loose teeth indicate presence of severe periodontal disease that has led to bone loss and consequently tooth mobility.[13] If participants did not report bleeding gums, painful gums, or loose teeth, they were defined as having an absence of periodontal disease.

2.3 | Covariates

2.3.1 | Demographics and lifestyle

Information on participant demographics (age, gender, ethnicity, deprivation-index, employment status, education level, household income) and BMI was collated during baseline attendance to UK Biobank assessment centres. Information on biomarkers such as blood pressure (systolic and diastolic) and resting heart rate were also acquired from attending UK Biobank assessment centres for baseline record.

Alcohol status (current, previous, or never), smoking history (never smoker or smoker), number of cigarettes smoked daily for current smokers, physical activity (length and frequency of engagement in moderate and vigorous-intensity activity in the previous week) were obtained from the Lifestyle and Environment Questionnaire when participants were at the UK Biobank Assessment Centre. We then further grouped the physical activity measure into days per week with none, moderate (1–3 days) and vigorous activity (>4 days). Addictions were reported according to "yes" or "no" responses from an item on the online mental health questionnaire which asked participants if they were ever "addicted to or dependent on one or more things, including substances (not cigarettes/coffee) or behaviours (such as gambling)". Total sugars (g), carbohydrate (g), energy (kJ) intake by 24-hour recall in the 'estimated nutrients yesterday' questionnaire were also extracted.

2.4 | Co-morbidities

The co-morbid diseases measured in UK Biobank at baseline and that were included in the analyses were: diabetes, cancer, hypertension, angina, cardiac arrest, myocardial infarction (MI), stroke, peripheral artery disease (PAD), heart failure, atrial fibrillation, inflammatory, respiratory, and metabolic conditions (including obesity and metabolic syndrome). Validated ICD-10 code lists[22] within the Cardiovascular Research Using Linked Bespoke Studies and Electronic Health Records (CALIBRE) resource were used to classify the aforementioned conditions,[25] and the presence of the appropriate ICD-10 code in a participant's health records denoted presence of the disease. The code list meanings were also adapted to identify relevant self-reported conditions that were not coded with ICD-10 classification. Participants were considered to have disease history if relevant ICD-10 codes were found in their health records, or if the condition was self-reported at the assessment centre. A history of hypertension was determined if ICD-10 code was present in health record data, or if the blood pressure reading from the assessment centre exceeded 140/90 mmHg.

2.5 | Statistical Analyses

Descriptive statistics for baseline characteristics were presented using frequencies (percentages) for categorical data and mean [standard deviation (SD)] or median [interquartile range (IQR)] for continuous variables depending on their distribution. Independent two-sample *t*-tests or Chi-square tests were performed to compare the mean or differences in proportion between psychosis and control groups. After assessing the uneven distribution of gender and age between psychosis and control groups, the control group were matched to the psychosis group by gender and age on a ratio 10:1 (note the psychosis group were younger and had more males than the control group). Secondly, among people with a history of psychosis, those with periodontal disease (self-reported painful gums, bleeding gums, or loose teeth) were compared with those without periodontal diseaseusing either *t*-tests or chi-square tests depending on the data type. Multivariable logistic regression modelling was then used to identify risk factors for periodontal disease among psychosis cases. The risk factors included in the model were any covariates with significance level <0.1 and those having <30% missing data. For highly correlated variables, e.g. deprivation index, education level, household income, only one of them were included in the modelling. Adjusted odds ratio were reported with 95% confidence intervals (95% CI).

Missing data were handled by multiple imputation, and Rubin's rule was used to combine the coefficients.[26] If a variable had >30% missing data, it was excluded from the modelling. To assess the impact of missing data, sensitivity analyses were performed using only the complete cases. All analyses were performed using the statistical software RStudio version 3[27] with various packages. Statistical significance level was set as 0.05.

3 | RESULTS

3.1 | Prevalence of Psychosis in the UK Biobank population

In total 502 505 participants who provided their information in the baseline measurement in the UK Biobank were included in the analysis. Of those, 6496 (1.3%) satisfied the presence of psychosis

as follows: 1547 participants (mean age 54.8 [SD 8.4], 54.2% male) had ICD-10 diagnosed psychosis, 2280 participants (mean age 54.8 [SD 8.1], 50.4% male) were on psychiatric medication, and 4216 participants (mean age 53.8 [SD 7.7], 43% male) self-reported psychotic experience. Lower proportion of white ethnicity was observed in groups diagnosed with psychosis or in those taking psychiatric medication when compared to general population controls (89.3% vs. 94.6%, 91.9% vs. 94.9%, respectively). People with a history of psychosis had a higher deprivation index (more deprived) in all of the three psychosis categories and had a much lower employment/self-employment rate and were at the lower end of household income (<£18 000) compared to controls.

3.2 | Prevalence of periodontal disease in participants with a history of psychosis

The prevalence of periodontal disease in people with a history of psychosis was significantly higher than the control group, regardless of whether the clinical group was defined by clinical diagnosis (ICD10) (21.3% cases vs. 14.8% controls, prevalence ratio (PR) 1.40, 95% confidence interval (CI): 1.26–1.56), anti-psychotic medication (20.4% cases vs. 15.6% controls, PR 1.30, 95% CI: 1.19–1.41), or self-reported psychotic experience (18.1% cases vs. 14.2% controls, PR 1.27, 95% CI: 1.19–1.36). (Table 1).

3.3 | Risk factors for periodontal disease in people with psychosis

Among participants with a history of psychosis, we further examined the potential risk factors including demographic characteristics, lifestyle, and pre-existing disease conditions for periodontal disease outcome (Table 2). This univariate analysis identified potential risk factors ($p < .1$) for inclusion in the final multivariable model.

3.4 | Identifying risk factors for periodontal disease among people with a history of psychosis

The fully adjusted models showed that, for clinically diagnosed psychosis cases by ICD 10, those who were younger, male and white had a lower risk of periodontal disease (OR = 0.96, 95% CI: 0.94–0.98; OR = 0.81, 95% CI: 0.67–0.98; OR = 0.64, 95% CI: 0.43–0.94, respectively) while living in deprivation (OR = 1.04, 95% CI: 1.00–1.08), having peripheral artery disease (OR = 2.08, 95% CI: 1.14–3.78) or respiratory disease (OR = 1.63, 95% CI: 1.20–2.21) increased the risk of periodontal disease (Table 3).

For those taking antipsychotic medication, being younger, male and white also reduced the risk of periodontal disease (OR = 0.97, 95% CI: 0.96–0.99; OR = 0.68, 95% CI: 0.58–0.80; OR = 0.62, 95% CI: 0.43–0.90, respectively), whilst smoking and respiratory disease increased the risk (OR = 1.74, 95% CI: 1.01–2.98; OR = 1.45, 95% CI: 1.10–1.91, respectively) (Table 3).

For those with self-reported psychotic experience, being younger and male reduced the risk of periodontal disease (OR = 0.99, 95% CI: 0.98–1.00; OR = 0.82, 95% CI: 0.73–0.92, respectively), while having smoking history and having cancer increased risk of periodontal disease (OR = 1.36, 95% CI: 1.08–1.70; OR = 1.33, 95% CI: 1.01–1.73, respectively).

A final logistic model that only included significant risk factors was undertaken to examine the robustness of the multivariable logistic model, the results of which are presented in Table S3, where the odds ratio of each risk factor remained unchanged or very similar to the original odds ratios in Table 3. Sensitivity analysis was reported using complete cases (excluding missing cases) and results were also consistent with imputed cases (Table S4).

4 | DISCUSSION

Our study utilized UK Biobank data to investigate the prevalence of periodontal disease among people with a history of psychosis, compared with general population. We used three categories to identify people with psychosis: clinical diagnosis ICD 10 code, self-reported medication, and information from mental health questions on psychotic experiences. Greater risk of periodontal disease (bleeding gums, painful gums and loose teeth) was observed in people with psychosis, regardless of the method of identification (clinical diagnosis, medication or self-report). Although the risk factors for poor oral health varied depending on how psychosis was identified, common demographic factors (being female, older or non-white) and unhealthy lifestyle such as smoking, or pre-existing comorbidities (heart disease, respiratory disease and cancer) increased the risk of periodontal disease. Our findings also confirmed that people with a history of psychosis were significantly more likely to have co-morbid diabetes than the control population - important because people with diabetes are prone to periodontal disease.[28] That said, co-morbid diabetes did not appear to confer extra susceptibility to periodontal disease.

To our knowledge, this is the first epidemiological study to investigate the determinants of periodontal disease in people with a history of psychosis using a large population cohort. Our research suggests that periodontal disease is not specific to people with a formal diagnosis but is prevalent across the psychosis continuum. The findings also suggest that those with a formal diagnosis of a psychotic disorder have a particularly high chance of having periodontal disease, which increases based on demographic characteristics (being female, non-white, and deprived), lifestyle (smoking, alcohol intake) and comorbidities namely heart disease, respiratory disease and cancer. Of these risk factors, smoking increased the risk of periodontal disease by almost 2-fold. This is a modifiable risk factor and amenable to intervention and should be targeted in healthcare planning by professionals involved in the care of people with psychosis.[28] In addition, lifestyle factors like smoking and alcohol intake are also

TABLE 1 Descriptive statistics comparing psychosis cases with matched comparison samples (ratio 1:10 matched by gender and age) from the UK Biobank participants

	Diagnosed by ICD10: F20-29			Taken psychiatric medication			Self reported psychotic experience in MHQ		
	Control	Case	*p*	Control	Case	*p*	Control	Case	*p*
	n = 15470	*n* = 1547		*n* = 22800	*n* = 2280		*n* = 42160	*n* = 4216	
Age, mean (SD)	54.8 (8.4)	54.8 (8.4)	1	54.8 (8.1)	54.8 (8.1)	1	53.8 (7.7)	53.8 (7.7)	1
Gender, male (%)	8380 (54.2)	838 (54.2)	1	11500 (50.4)	1150 (50.4)	1	18140 (43.0)	1814 (43.0)	1
Ethnicity, white (%)	14467 (94.6)	1323 (89.3)	<0.001	21374 (94.9)	2046 (91.9)	<0.001	40625 (97.3)	4032 (96.9)	0.11
Deprivation index, mean (SD)	−1.2 (3.1)	1.5 (3.7)	<0.001	−1.2 (3.1)	0.9 (3.7)	<0.001	−1.6 (2.9)	−0.9 (3.2)	<0.001
Employment (%)									
Employed/self-employed	9862 (64.5)	346 (23.0)	<0.001	14642 (65.0)	506 (22.5)	<0.001	30182 (72.1)	2767 (66.2)	<0.001
Other	1287 (8.4)	695 (46.1)		1867 (8.3)	1049 (46.7)		2524 (6.0)	574 (13.7)	
Retired	4143 (27.1)	465 (30.9)		6012 (26.7)	689 (30.7)		9153 (21.9)	839 (20.1)	
Education, college or above (%)	5103 (39.8)	393 (35.7)	0.009	7656 (40.5)	587 (35.4)	<0.001	19575 (49.7)	2084 (52.9)	<0.001
Household Income, £ (%)									
<18000	2813 (21.2)	750 (65.8)	<0.001	3888 (19.9)	1115 (62.7)	<0.001	4583 (12.0)	878 (23.0)	<0.001
18000–30999	3104 (23.4)	221 (19.4)		4753 (24.3)	341 (19.2)		8056 (21.0)	865 (22.6)	
31000–51999	3581 (27.0)	96 (8.4)		5248 (26.8)	217 (12.2)		11229 (29.3)	1061 (27.7)	
52000–100000	2949 (22.2)	56 (4.9)		4446 (22.7)	80 (4.5)		11001 (28.7)	830 (21.7)	
>100000	829 (6.2)	16 (1.4)		1234 (6.3)	26 (1.5)		3429 (9.0)	190 (5.0)	
BMI, mean (SD)	27.5 (4.7)	28.7 (5.8)	<0.001	27.4 (4.8)	29.5 (6.0)	<0.001	26.7 (4.6)	27.8 (5.5)	<0.001
Systolic blood pressure (mmHG), mean (SD)	135.5 (18.2)	132.1 (18.9)	<0.001	135.1 (18.4)	130.8 (18.1)	<0.001	132.8 (17.7)	131.7 (17.9)	<0.001
Diastolic blood pressure (mmHG), mean (SD)	82.5 (10.4)	81.9 (10.9)	0.026	82.4 (10.3)	81.9 (10.8)	0.048	81.5 (10.1)	81.6 (10.3)	0.718
Resting heart rate (BPM), mean (SD)	62.9 (10.7)	64.9 (11.0)	0.29	62.5 (10.4)	66.2 (11.1)	0.003	62.4 (10.5)	63.9 (10.7)	<0.001
Alcohol status (%)									
Current	14242 (92.4)	1153 (75.8)	<0.001	20909 (92.0)	1725 (76.1)	<0.001	39801 (94.5)	3814 (90.6)	<0.001
Previous	505 (3.3)	227 (14.9)		810 (3.6)	321 (14.2)		1124 (2.7)	267 (6.3)	
Never	674 (4.4)	141 (9.3)		999 (4.4)	220 (9.7)		1204 (2.9)	128 (3.0)	
History of smoking (%)	9202 (86.0)	1055 (97.0)	<0.001	13377 (85.3)	1496 (94.3)	<0.001	24755 (69.2)	2820 (76.9)	<0.001
Cigarette amount, mean (SD)	19.0 (10.5)	23.9 (15.3)	<0.001	18.9 (10.1)	23.4 (12.7)	<0.001	17.9 (9.5)	19.5 (10.8)	<0.001
Addiction (%)	329 (6.9)	32 (19.0)	<0.001	475 (6.6)	77 (21.0)	<0.001	2511 (6.0)	718 (17.4)	<0.001
Moderate to vigorous physical activity per week (%)									
None	2232 (14.4)	447 (28.9)	<0.001	3340 (14.6)	684 (30.0)	<0.001	4966 (11.8)	635 (15.1)	<0.001
1–3 days	3368 (21.8)	341 (22.0)		4980 (21.8)	561 (24.6)		10681 (25.3)	1026 (24.3)	
>4 days	9870 (63.8)	759 (49.1)		14480 (63.5)	1035 (45.4)		26513 (62.9)	2555 (60.6)	

(Continues)

TABLE 1 (Continued)

	Diagnosed by ICD10: F20-29			Taken psychiatric medication			Self reported psychotic experience in MHQ		
	Control	Case	*p*	Control	Case	*p*	Control	Case	*p*
	n = 15 470	*n* = 1547		*n* = 22 800	*n* = 2280		*n* = 42 160	*n* = 4216	
Daily sugar intake (g), mean (SD)	124.6 (60.0)	148.9 (89.8)	<0.001	123.2 (62.6)	137.2 (69.9)	0.001	122.2 (58.7)	129.2 (64.3)	0.002
Daily carbohydrate intake (g), mean (SD)	262.5 (106.7)	303.6 (161.7)	<0.001	260.1 (109.4)	276.9 (124.8)	0.022	258.2 (103.7)	265.5 (109.3)	0.059
Daily energy intake (kJ), mean (SD)	9014.1 (3244.3)	9787.1 (4581.5)	0.006	8950.3 (3368.4)	9019.9 (3638.4)	0.757	8867.0 (3094.5)	9161.9 (3292.9)	0.01
Depression, (%)	578 (3.7)	612 (39.6)	<0.001	845 (3.7)	835 (36.6)	<0.001	996 (2.4)	417 (9.9)	<0.001
Anxiety, (%)	360 (2.3)	352 (22.8)	<0.001	530 (2.3)	460 (20.2)	<0.001	650 (1.5)	245 (5.8)	<0.001
Diabetes (%)	967 (6.3)	303 (19.6)	<0.001	1312 (5.8)	355 (15.6)	<0.001	1371 (3.3)	257 (6.1)	<0.001
Cancer (%)	1806 (11.7)	253 (16.4)	<0.001	2646 (11.6)	306 (13.4)	0.011	3941 (9.3)	372 (8.8)	0.276
Hypertension (%)	3260 (21.1)	602 (38.9)	<0.001	4643 (20.4)	718 (31.5)	<0.001	5836 (13.8)	745 (17.7)	<0.001
Angina (%)	748 (4.8)	154 (10.0)	<0.001	1032 (4.5)	178 (7.8)	<0.001	1078 (2.6)	186 (4.4)	<0.001
Cardiac arrest (%)	90 (0.6)	28 (1.8)	<0.001	133 (0.6)	30 (1.3)	<0.001	127 (0.3)	21 (0.5)	0.044
Myocardial infarction (%)	513 (3.3)	100 (6.5)	<0.001	694 (3.0)	111 (4.9)	<0.001	742 (1.8)	107 (2.5)	<0.001
Stroke (%)	307 (2.0)	80 (5.2)	<0.001	479 (2.1)	89 (3.9)	<0.001	468 (1.1)	67 (1.6)	0.007
Peripheral artery disease (%)	237 (1.5)	63 (4.1)	<0.001	363 (1.6)	55 (2.4)	0.005	403 (1.0)	51 (1.2)	0.13
Heart failure (%)	236 (1.5)	93 (6.0)	<0.001	346 (1.5)	92 (4.0)	<0.001	252 (0.6)	56 (1.3)	<0.001
Atrial fibrillation (%)	609 (3.9)	122 (7.9)	<0.001	859 (3.8)	107 (4.7)	0.033	1074 (2.5)	126 (3.0)	0.095
Inflammatory disease (%)	2309 (14.9)	352 (22.8)	<0.001	3437 (15.1)	414 (18.2)	<0.001	4943 (11.7)	588 (13.9)	<0.001
Respiratory disease (%)	1375 (8.9)	353 (22.8)	<0.001	2081 (9.1)	423 (18.6)	<0.001	2976 (7.1)	465 (11.0)	<0.001
Metabolic disease (%)	1997 (12.9)	434 (28.1)	<0.001	2807 (12.3)	519 (22.8)	<0.001	3671 (8.7)	552 (13.1)	<0.001
Periodontal disease[a] (%)	2266 (14.8)	318 (21.3)	<0.001	3512 (15.6)	455 (20.4)	<0.001	5937 (14.2)	756 (18.1)	<0.001
Periodontal disease severity[a] (%)									
No periodontal disease	13 005 (85.1)	1172 (78.7)	<0.001	19 110 (84.8)	1773 (79.6)	<0.001	35 876 (85.8)	3430 (81.9)	<0.001
Mild to moderate	1900 (12.4)	250 (16.8)		2888 (12.8)	366 (16.4)		5203 (12.4)	661 (15.8)	
Severe	381 (2.5)	68 (4.6)		533 (2.4)	89 (4.0)		730 (1.7)	95 (2.3)	

Note: The psychosis cases were identified by using: (1) ICD10 code: F20-29, (2) one or more psychiatric medication taken, and (3) self-reported psychotic experience in the Mental Health Questionnaire. Means and percentages are calculated for variables excluding missing data. There was missing data in the following variables: resting heart rate (92%), sugar intake (86%), carbohydrate intake (86%), energy intake (86%), cigarette amount (77%), addiction (69%), smoking history (31%), education (19%), household income (15%), blood pressure both systolic and diastolic (6%), periodontal disease (1.2%), employment (1.1%), ethnicity (1.1%), BMI (0.6%), alcohol status (0.3%), deprivation index (0.1%).

Abbreviations: BMI, body mass index; MHQ, mental health questionnaire; *n*, number of participants; SD, standard deviation.

[a]Periodontal disease is defined as participants having painful gum/bleeding gum (as mild to moderate) or loose teeth (as severe) in the self-reported oral health question.

TABLE 2 Descriptive table for periodontal disease status among participants with a history of psychosis (1, diagnosed by ICD10; 2, by medication; or 3, by self-reported psychosis-like experience in the mental health questionnaire)

	Diagnosed by ICD10: F20-29			Taken psychiatric medication			Self reported psychotic experience in MHQ		
	Normal OH	Periodontal disease[a]	*p*	Normal OH	Periodontal disease[a]	*p*	Normal OH	Periodontal disease[a]	*p*
	n = 1172	*n* = 318		*n* = 1773	*n* = 455		*n* = 3430	*n* = 756	
Age, mean (SD)	55.4 (8.3)	52.4 (8.3)	<0.001	55.2 (8.0)	53.2 (8.1)	<0.001	53.9 (7.8)	53.2 (7.3)	0.014
Gender, male (%)	648 (55.3)	156 (49.1)	0.056	924 (52.1)	190 (41.8)	<0.001	1512 (44.1)	290 (38.4)	0.005
Ethnicity, white (%)	1035 (90.9)	251 (82.8)	<0.001	1625 (93.2)	383 (87.2)	<0.001	3292 (97.0)	713 (96.4)	0.452
Deprivation index, mean (SD)	1.2 (3.8)	2.2 (3.6)	<0.001	0.7 (3.7)	1.3 (3.6)	0.002	−0.9 (3.2)	−0.6 (3.3)	0.02
Employment (%)									
Employed/self-employed	273 (23.8)	66 (21.0)	0.001	411 (23.5)	89 (19.7)	0.001	2258 (66.3)	494 (66.0)	<0.001
Other	501 (43.6)	174 (55.2)		776 (44.4)	244 (54.1)		430 (12.6)	138 (18.4)	
Retired	375 (32.6)	75 (23.8)		560 (32.1)	118 (26.2)		716 (21.0)	117 (15.6)	
Education, college or above (%)	311 (36.0)	79 (34.6)	0.756	469 (36.1)	114 (32.9)	0.309	1718 (53.3)	362 (50.8)	0.25
Household Income, £ (%)									
<18000	566 (63.5)	179 (74.3)	0.014	859 (61.6)	249 (66.0)	0.33	673 (21.6)	204 (29.3)	<0.001
18000–30999	187 (21.0)	33 (13.7)		277 (19.9)	64 (17.0)		709 (22.7)	153 (22.0)	
31000–51999	77 (8.6)	19 (7.9)		169 (12.1)	48 (12.7)		885 (28.3)	176 (25.3)	
52000–100000	50 (5.6)	6 (2.5)		67 (4.8)	12 (3.2)		685 (21.9)	144 (20.7)	
>100000	12 (1.3)	4 (1.7)		22 (1.6)	4 (1.1)		170 (5.4)	20 (2.9)	
BMI, mean (SD)	28.5 (5.6)	29.5 (6.4)	0.01	29.4 (6.0)	29.8 (6.1)	0.182	27.8 (5.4)	28.1 (5.8)	0.142
Systolic blood pressure (mmHG), mean (SD)	132.8 (19.2)	130.2 (18.1)	0.031	130.7 (18.0)	131.2 (18.8)	0.574	131.9 (17.8)	130.8 (17.8)	0.133
Diastolic blood pressure (mmHG), mean (SD)	81.9 (10.8)	82.2 (11.4)	0.706	81.6 (10.7)	83.1 (11.2)	0.009	81.7 (10.2)	81.2 (10.6)	0.229
Resting heart rate (BPM), mean (SD)	63.7 (8.5)	73.4 (18.9)	0.07	66.2 (10.6)	66.4 (13.6)	0.945	63.6 (10.7)	65.3 (10.6)	0.112
Alcohol status (%)									
Current	903 (77.3)	228 (72.8)	0.05	1358 (76.8)	340 (75.1)	0.08	3107 (90.6)	682 (90.5)	0.989
Previous	171 (14.6)	46 (14.7)		251 (14.2)	57 (12.6)		218 (6.4)	49 (6.5)	
Never	94 (8.0)	39 (12.5)		159 (9.0)	56 (12.4)		104 (3.0)	23 (3.1)	
History of smoking (%)	822 (96.6)	208 (98.1)	0.357	1164 (93.5)	296 (96.7)	0.043	2266 (76.0)	542 (81.3)	0.004
Cigarette amount, mean (SD)	24.1 (15.7)	24.2 (13.9)	0.928	23.5 (12.9)	23.0 (11.9)	0.763	19.5 (10.2)	19.7 (12.5)	0.792
Addiction (%)	22 (17.2)	10 (26.3)	0.308	69 (22.4)	7 (12.5)	0.134	569 (16.9)	145 (19.8)	0.072
Moderate to vigorous physical activity per week (%)									

(Continues)

TABLE 2 (Continued)

	Diagnosed by ICD10: F20-29			Taken psychiatric medication			Self reported psychotic experience in MHQ		
	Normal OH	Periodontal disease[a]	*p*	Normal OH	Periodontal disease[a]	*p*	Normal OH	Periodontal disease[a]	*p*
	n = 1172	*n* = 318		*n* = 1773	*n* = 455		*n* = 3430	*n* = 756	
None	325 (27.7)	94 (29.6)	0.476	535 (30.2)	134 (29.5)	0.712	509 (14.8)	117 (15.5)	0.24
1–3 days	253 (21.6)	75 (23.6)		423 (23.9)	117 (25.7)		820 (23.9)	200 (26.5)	
>4 days	594 (50.7)	149 (46.9)		815 (46.0)	204 (44.8)		2101 (61.3)	439 (58.1)	
Daily sugar intake (g), mean (SD)	149.4 (93.3)	139.9 (71.5)	0.582	137.1 (66.7)	136.4 (83.0)	0.956	129.7 (64.9)	126.1 (61.5)	0.536
Daily carbohydrate intake (g), mean (SD)	305.7 (164.4)	284.4 (144.0)	0.491	276.5 (118.7)	276.7 (149.1)	0.993	265.2 (111.4)	264.6 (97.5)	0.948
Daily energy intake (kJ), mean (SD)	9854.4 (4495.5)	9249.6 (4622.4)	0.489	8984.5 (3378.2)	9156.9 (4616.5)	0.77	9197.8 (3330.2)	8940.1 (3028.0)	0.381
Depression, (%)	456 (38.9)	132 (41.5)	0.437	664 (37.5)	158 (34.7)	0.308	329 (9.6)	82 (10.8)	0.326
Anxiety, (%)	257 (21.9)	81 (25.5)	0.207	349 (19.7)	104 (22.9)	0.151	196 (5.7)	46 (6.1)	0.757
Diabetes (%)	221 (18.9)	66 (20.8)	0.496	262 (14.8)	81 (17.8)	0.128	200 (5.8)	53 (7.0)	0.251
Cancer (%)	203 (17.3)	42 (13.2)	0.095	248 (14.0)	49 (10.8)	0.085	291 (8.5)	79 (10.4)	0.098
Hypertension (%)	452 (38.6)	124 (39.0)	0.941	553 (31.2)	141 (31.0)	0.979	598 (17.4)	139 (18.4)	0.569
Angina (%)	110 (9.4)	37 (11.6)	0.277	141 (8.0)	32 (7.0)	0.578	140 (4.1)	43 (5.7)	0.063
Cardiac arrest (%)	23 (2.0)	5 (1.6)	0.825	25 (1.4)	5 (1.1)	0.775	17 (0.5)	4 (0.5)	1
Myocardial infarction (%)	71 (6.1)	24 (7.5)	0.404	85 (4.8)	21 (4.6)	0.971	87 (2.5)	20 (2.6)	0.964
Stroke (%)	59 (5.0)	18 (5.7)	0.761	76 (4.3)	10 (2.2)	0.054	58 (1.7)	8 (1.1)	0.27
Peripheral artery disease (%)	41 (3.5)	20 (6.3)	0.039	40 (2.3)	14 (3.1)	0.398	41 (1.2)	9 (1.2)	1
Heart failure (%)	63 (5.4)	26 (8.2)	0.083	66 (3.7)	23 (5.1)	0.246	44 (1.3)	10 (1.3)	1
Atrial fibrillation (%)	92 (7.8)	25 (7.9)	1	86 (4.9)	20 (4.4)	0.777	107 (3.1)	17 (2.2)	0.246
Inflammatory disease (%)	270 (23.0)	68 (21.4)	0.583	335 (18.9)	70 (15.4)	0.096	481 (14.0)	100 (13.2)	0.607
Respiratory disease (%)	243 (20.7)	100 (31.4)	<0.001	307 (17.3)	103 (22.6)	0.011	371 (10.8)	91 (12.0)	0.365
Metabolic disease (%)	323 (27.6)	90 (28.3)	0.848	410 (23.1)	94 (20.7)	0.29	431 (12.6)	114 (15.1)	0.072
Disease incidence, mean (SD)	1.9 (1.9)	2.0 (2.2)	0.159	1.5 (1.8)	1.5 (1.8)	0.767	0.8 (1.3)	0.9 (1.3)	0.172
Had disease history (%)	796 (67.9)	221 (69.5)	0.639	1023 (57.7)	260 (57.1)	0.872	1407 (41.0)	331 (43.8)	0.176

Note: Means and percentages are calculated for variables excluding missing data. There was missing data in the following variables in any of the three ways of identification of people with a history of psychosis stated above: resting heart rate (83%–98%), sugar intake (81%–90%), carbohydrate intake (81%–90%), energy intake (81%–90%), cigarette amount (74%–81%), addiction (2%–89%), smoking history (13%–30%), education (6%–29%), household income (9%–26%), blood pressure both systolic and diastolic (4.2%–6.4%), ethnicity (1.3%–4.2%), employment (0.8%–2.6%), BMI (0.1%–2.2%), alcohol status (0.1%–1.7%), deprivation index (0.2%–0.3%), and periodontal disease (0.7%–3.7%).

Abbreviations: BMI, body mass index; MHQ, mental health questionnaire; *n*, number of participants; SD, standard deviation.

[a]periodontal disease is defined by participants having painful gum, bleeding gum or loose teeth in the self-reported oral health question.

TABLE 3 Risk factors of periodontal disease in participants with a history of psychosis diagnosed by 1. ICD10, 2. by medication, or 3. by self-reported psychosis-like experience in the mental health questionnaire, multiple imputed cases

	1. Diagnosed by ICD10: F20-29			2. Taken psychiatric medication			3. Self reported psychotic experience in MHQ		
	n = 1547			*n* = 2280			*n* = 4216		
	Overall PD, OR (95% CI)[a,b]	Mild/moderate PD, OR (95% CI)	Severe PD, OR (95% CI)	Overall PD, OR (95% CI)	Mild/moderate PD, OR (95% CI)	Severe PD, OR (95% CI)	Overall PD, OR (95% CI)	Mild/moderate PD, OR (95% CI)	Severe PD, OR (95% CI)
Age	0.96*** (0.94–0.98)	0.95*** (0.93–0.97)	1.01 (0.98–1.05)	0.97*** (0.96–0.99)	0.96*** (0.95–0.98)	1.02 (0.99–1.05)	0.99* (0.98–1.00)	0.98** (0.97–0.99)	1.02 (0.99–1.05)
Gender, male	0.81* (0.67–0.98)	0.77* (0.62–0.95)	1.00 (0.69–1.45)	0.68*** (0.58–0.80)	0.67*** (0.56–0.80)	0.76 (0.55–1.05)	0.82** (0.73–0.92)	0.80*** (0.71–0.91)	0.96 (0.72–1.30)
Ethnicity, white	0.64* (0.43–0.94)	0.67 (0.43–1.04)	0.54 (0.25–1.17)	0.62* (0.43–0.90)	0.72 (0.48–1.08)	0.36** (0.19–0.68)	0.86 (0.55–1.34)	0.88 (0.55–1.42)	0.75 (0.26–2.14)
Deprivation index	1.04* (1.00–1.08)	1.02 (0.98–1.07)	1.10* (1.02–1.18)	1.03 (1.00–1.06)	1.02 (0.98–1.05)	1.09** (1.02–1.16)	1.02 (1.00–1.05)	1.02 (0.99–1.05)	1.03 (0.97–1.10)
BMI	1.01 (0.99–1.04)	1.02 (1.00–1.05)	0.96 (0.92–1.01)	1.00 (0.98–1.02)	1.01 (0.99–1.01)	0.97 (0.93–1.01)	1.01 (0.99–1.02)	1.01 (1.00–1.03)	0.98 (0.94–1.03)
Systolic blood pressure	0.99 (0.98–1.00)	0.99 (0.98–1.00)	1.00 (0.98–1.01)	1.00 (0.99–1.01)	1.00 (0.99–1.01)	1.00 (0.99–1.02)	1.00 (0.99–1.01)	1.00 (0.99–1.01)	1.01 (0.99–1.02)
Diastolic blood pressure	1.01 (0.99–1.03)	1.02 (1.00–1.04)	0.99 (0.96–1.02)	1.01 (1.00–1.03)	1.02 (1.00–1.03)	1.00 (0.98–1.03)	1.00 (0.98–1.01)	1.00 (0.98–1.01)	1.00 (0.97–1.03)
Alcohol status									
Current (ref)	1	1	1	1	1	1	1	1	1
Previous	0.96 (0.66–1.39)	1.05 (0.70–1.59)	0.72 (0.34–1.53)	0.89 (0.65–1.22)	0.82 (0.57–1.17)	1.14 (0.62–2.10)	0.97 (0.70–1.34)	0.96 (0.68–1.36)	1.01 (0.45–2.25)
Never	1.31 (0.84–2.03)	1.32 (0.82–2.12)	1.19 (0.49–2.94)	1.23 (0.86–1.75)	1.20 (0.81–1.78)	1.40 (0.72–2.72)	0.94 (0.59–1.51)	0.97 (0.59–1.58)	0.71 (0.17–3.04)
History of smoking	1.53 (0.56–4.14)	1.27 (0.47–3.47)	NA	1.74* (1.01–2.98)	1.57 (0.90–2.74)	NA	1.36** (1.08–1.70)	1.25 (0.99–1.58)	3.14** (1.45–6.81)
Moderate to vigorous physical activity per week									
None (ref)	1	1	1	1	1	1	1	1	1
1–3 days	1.02 (0.71–1.46)	1.02 (0.68–1.52)	1.10 (0.54–2.26)	1.13 (0.85–1.50)	1.17 (0.86–1.60)	1.08 (0.58–2.00)	1.10 (0.85–1.42)	1.20 (0.92–1.58)	0.54 (0.27–1.08)
>4 days	0.91 (0.67–1.23)	0.90 (0.64–1.26)	0.98 (0.54–1.77)	0.99 (0.77–1.28)	0.98 (0.74–1.30)	1.14 (0.68–1.89)	0.94 (0.75–1.19)	0.97 (0.76–1.24)	0.80 (0.47–1.38)
Cancer	0.93 (0.63–1.36)	0.78 (0.50–1.24)	1.28 (0.67–2.42)	0.84 (0.60–1.18)	0.84 (0.57–1.23)	0.84 (0.44–1.62)	1.33* (1.01–1.73)	1.36* (1.02–1.80)	1.12 (0.56–2.22)
Angina	1.24 (0.78–1.96)	1.01 (0.59–1.72)	2.08 (0.96–4.51)	0.98 (0.62–1.55)	0.81 (0.47–1.38)	1.80 (0.82–3.93)	1.38 (0.94–2.03)	1.45 (0.96–2.19)	1.09 (0.46–2.60)

(Continues)

TABLE 3 (Continued)

Peripheral artery disease	2.08* (1.14–3.78)	1.98 (0.98–3.98)	2.16 (0.83–5.62)	1.74 (0.89–3.40)	2.30* (1.11–4.76)	0.73 (0.16–3.36)	0.98 (0.47–2.07)	0.92 (0.40–2.09)	1.17 (0.26–5.21)
Heart failure	1.59 (0.94–2.70)	1.80 (1.00–3.24)	1.19 (0.45–3.18)	1.70 (1.00–2.88)	2.28** (1.30–4.01)	0.48 (0.11–2.14)	0.95 (0.46–1.96)	0.80 (0.34–1.84)	1.51 (0.41–5.52)
Inflammatory disease	0.89 (0.64–1.25)	0.89 (0.61–1.29)	0.99 (0.53–1.86)	0.78 (0.57–1.06)	0.72 (0.51–1.02)	0.96 (0.54–1.71)	0.88 (0.69–1.12)	0.88 (0.68–1.15)	0.84 (0.46–1.53)
Respiratory disease	1.63 (1.20–2.21)**	1.64** (1.17–2.29)	1.50 (0.84–2.70)	1.45** (1.10–1.91)	1.41* (1.04–1.91)	1.57 (0.91–2.71)	1.05 (0.81–1.35)	0.99 (0.75–1.30)	1.41 (0.79–2.51)
Metabolic disease	0.90 (0.65–1.24)	1.05 (0.73–1.51)	0.51 (0.26–1.02)	0.82 (0.61–1.10)	0.86 (0.62–1.18)	0.65 (0.35–1.21)	1.21 (0.94–1.56)	1.13 (0.86–1.48)	1.80* (1.01–3.20)

[a]OR and 95% CI were pooled over the 5 imputed datasets.

[b]Logistic regression was used to assess the risk factors of the periodontal disease (PD) outcomes among people with a history of psychosis. All models contain covariates of demographics (age, gender, ethnicity, deprivation index), lifestyles (BMI, blood pressure, alcohol status, smoking history, physical activity), comorbidities (cancer, angina, PAD, heart failure, inflammatory, respiratory, metabolic disease).

*$p < .05$; **$p < 0/01$; ***$p < .001$.

risk factors for not only periodontal disease but co-morbid conditions particularly cardiovascular and respiratory disease, which were identified in our findings. Interventions targeted to modify these factors will not only have an impact on oral health of those with psychosis but can also improve general health of this population.[29]

There are limitations of note. First, the UK Biobank was a self-report questionnaire-based study with relatively healthy voluntary participation. It is therefore possible that the participants reported less severe experiences of psychosis and periodontal disease than the population in general. However, the prevalence of psychosis in the UK Biobank cohort compared to the general UK population was similar with a prevalence of psychosis cases (3/1000) in UK Biobank as compared to 4/1000 (95% CI: 3–7/1000) prevalence for the whole UK population.[30] The results of our study are therefore likely to be generalisable to population-based samples of people with psychosis from UK Biobank because the assessment of exposure-disease relationship does not require participants to be representative of the population at large.[31] However, more severe cases of psychosis requiring hospitalization and regular carer support might be less likely to have participated in our study. It would be reasonable to assume that such severe cases will have worse oral health and associations observed in our study would be an underestimate in those groups. Furthermore, where we used self-reported medication as a diagnostic group, it is possible that we may have overestimated cases of psychosis in this group as some anti-psychotic medications may have been used to treat conditions like epilepsy rather than psychosis. That said, the results in the medication group did not differ markedly from the other groups (IDC-10 and self-reported psychosis experience) and we were thus able to 'cross-validate' the results of the medication only group. Furthermore, the only situation where a drug used to treat epilepsy could be confused with a drug to treat a major psychiatric disorder is mood-stabilizing drugs like sodium valproate which are also used to treat bipolar disorder. Our table of drugs (Table S1) confirms that we only included antipsychotics and did not include mood stabilizers and therefore are unlikely to have included medications used for a condition other than psychosis. Another limitation is the oral health measure; bleeding gums, painful gum or loose teeth were used as surrogates for periodontal disease and although they have demonstrated their validity in the absence of a clinical diagnosis,[23,24] they were not validated by clinical examination.

The findings of our study highlight the importance of improving and protecting the oral health of people with a history of psychosis, so as to prevent tooth loss through periodontal disease. A recent meta-analysis has indicated low frequency of dental visiting and tooth brushing in people with psychosis.[5] Therefore, healthcare professionals, both dental and psychiatric, need to work together to tackle barriers for dental care and promote oral hygiene behaviours in people with a history of psychosis. It may also be possible to target modifiable risk factors such as smoking and alcohol intake that increase the risk of periodontal disease and other co-morbid conditions. A consensus statement has recently been issued providing

five-year targets on how improvements in oral health in severe mental illness could be achieved.[32]

5 | CONCLUSION

Prevalence of periodontal disease is higher in people with a history of psychotic experiences, people taking anti-psychotic medication, and with formal diagnoses of psychotic disorders, when compared to the general population. Oral health should be an integral part of health care plans for people with psychosis with early intervention and prevention being initiated at the point of diagnosis. Modifiable risk factors like smoking, which increase risk of periodontal disease, need to be incorporated in health promotion programmes for this population.

CONFLICT OF INTEREST

This work was supported by the Closing the Gap network. Closing the Gap is funded by UK Research and Innovation (UKRI) and their support is gratefully acknowledged (Grant number: ES/S004459/1). Any views expressed here are those of the project investigators and do not necessarily represent the views of the Closing the Gap network or UKRI. DS is expert advisor to the National Institute of Clinical Excellence (NICE) UK centre for guidelines. The authors have no other conflicts of interest to declare. Views expressed are those of the authors, and not those of NICE.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in UK Biobank at https://www.ukbiobank.ac.uk, reference number 54633.

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REFERENCES

1. Department Of Health. Choosing better oral health: an oral health plan for England. 2005. Epub 19 November 2021. https://www.gov.uk/government/publications/delivering-better-oral-health-an-evidence-based-toolkit-for-prevention Accessed February 25, 2022.
2. Cormac I, Jenkins P. Understanding the importance of Oral health in psychiatric patients. *Adv Psychiatr Treat*. 1999;5(1):53-60.
3. Yang M, Chen P, He MX, et al. Poor oral health in patients with schizophrenia: a systematic review and meta-analysis. *Schizophr Res*. 2018;1(201):3-9.
4. Report of the British Society for Disability and oral Health Working Group. Report of the British Society for Disability and oral Health Working Group. 2000. http://www.bsdh.org/documents/mental.pdf Accessed February 25, 2022.
5. Turner E, Berry K, Aggarwal VR, Quinlivan L, Villanueva T, Palmier-Claus J. Oral health self-care behaviours in serious mental illness: a systematic review and meta-analysis. *Acta Psychiatr Scand*. 2022;145(1):29-41.
6. Kilbourne A, Horvitz-Lennon M, Post E, et al. Oral health in veterans affairs patients diagnosed with serious mental illness. *J Public Health Dent*. 2007;67(1):42-48.
7. Palmier-Claus JE, Shiers D, French P, Harris R, Laverty L. Oral health in psychosis: an unmet need. *Schizophr Res*. 2019;1(204):442.
8. Mirza I. Oral health of psychiatric in-patients: a point prevalence survey of an inner-city hospital. *Psychiatri bull*. 2001;25(4):143-145.
9. Eltas A, Kartalcı S, Eltas SD, Dündar S, Uslu MO. An assessment of periodontal health in patients with schizophrenia and taking anti-psychotic medication. *Int J Dent Hyg*. 2013;11(2):78-83.
10. Friedlander A, Marder S. The psychopathology, medical management and dental implications of schizophrenia. *J Am Dent Assoc*. 2002;133(5):603-610.
11. Matevosyan N. Oral health of adults with serious mental illnesses: a review. *Community Ment Health J*. 2010;46(6):553-562.
12. McCreadie R, Stevens H, Henderson J, et al. The dental health of people with schizophrenia. *Acta Psychiatr Scand*. 2004;110(4):306-310.
13. Papapanou PN, Sanz M, Buduneli N, et al. Periodontitis: consensus report of workgroup 2 of the 2017 world workshop on the classification of periodontal and peri-implant diseases and conditions. *J Clin Periodontol*. 2018;45(Suppl 20):S162-S170.
14. Ferreira MC, Dias-Pereira AC, Branco-de-Almeida LS, Martins CC, Paiva SM. Impact of periodontal disease on quality of life: a systematic review. *J Periodontal Res*. 2017;52(4):651-665.
15. Nascimento GG, Leite FRM, Vestergaard P, Scheutz F, López R. Does diabetes increase the risk of periodontitis? A systematic review and meta-regression analysis of longitudinal prospective studies. *Acta Diabetol*. 2018 Jul;55(7):653-667.
16. Larvin H, Kang J, Aggarwal VR, Pavitt S, Wu J. Risk of incident cardiovascular disease in people with periodontal disease: a systematic review and meta-analysis. *Clin Exp Dent Res*. 2021;7:109-122.
17. Johns LC, Van Os J. The continuity of psychotic experiences in the general population. *Clin Psychol Rev*. 2001;21(8):1125-1141.
18. Nelson B, Fusar-Poli P, Yung AR. Can we detect psychotic-like experiences in the general population? *Curr Pharm des*. 2012;18(4):376-385.
19. Davis KAS, Cullen B, Adams M, et al. Indicators of mental disorders in UK biobank–A comparison of approaches. *Int J Methods Psychiatr Res*. 2019;28:e1796.
20. UK Biobank. *UK Biobank: Rationale Design and Development of a Large-Scale Prospective Resource*. UK Biobank Coordinating Centre; 2007.
21. Sudlow C, Gallacher J, Allen N, et al. UK biobank: an open access resource for identifying the causes of a wide range of complex diseases of middle and old age. *PLoS Med*. 2015;12:e1001779.
22. World Health Organization. (2004). *ICD-10: International statistical classification of diseases and related health problems: tenth revision*, 2nd ed. World Health Organization. https://apps.who.int/iris/handle/10665/42980
23. Larvin H, Wilmott S, Wu J, Kang J. The impact of periodontal disease on hospital admission and mortality during COVID-19 pandemic. *Front Med (Lausanne)*. 2020;7:604980.
24. Abbood HM, Hinz J, Cherukara G, Macfarlane TV. Validity of self-reported periodontal disease: a systematic review and meta-analysis. *J Periodontol*. 2016;87:1474-1483.
25. Denaxas SC, George J, Herrett E, et al. Data resource profile: cardiovascular disease research using linked bespoke studies and electronic health records (CALIBER). *Int J Epidemiol*. 2012;41:1625-1638.
26. Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. Wiley-Interscience; 2004.
27. R Core Team (2021). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, . https://www.R-project.org/

28. Preshaw PM, Alba AL, Herrera D, et al. Periodontitis and diabetes: a two-way relationship. *Diabetologia*. 2012;55:21-31.
29. Gilbody S, Peckham E, Bailey D, et al. Smoking cessation in severe mental illness: combined long-term quit rates from the UK SCIMITAR trials programme. *Br J Psychiatry*. 2021;218(2):95-97.
30. Kirkbride JB, Errazuriz A, Croudace TJ, et al. Incidence of schizophrenia and other psychoses in England, 1950-2009: a systematic review and meta-analyses. *PLoS One*. 2012;7:e31660.
31. Fry A, Littlejohns TJ, Sudlow C, et al. Comparison of sociodemographic and health-related characteristics of UK biobank participants with the general population. *Am J Epidemiol*. 2017;186(9):1026-1034.
32. The Closing the Gap Research Group, (2022). The right to smile consensus statement. www.lancaster.ac.uk/right-to-smile-project

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: Kang J, Palmier-Claus J, Wu J, et al. Periodontal disease in people with a history of psychosis: Results from the UK biobank population-based study. *Community Dent Oral Epidemiol*. 2022;00:1-12. doi: 10.1111/cdoe.12798