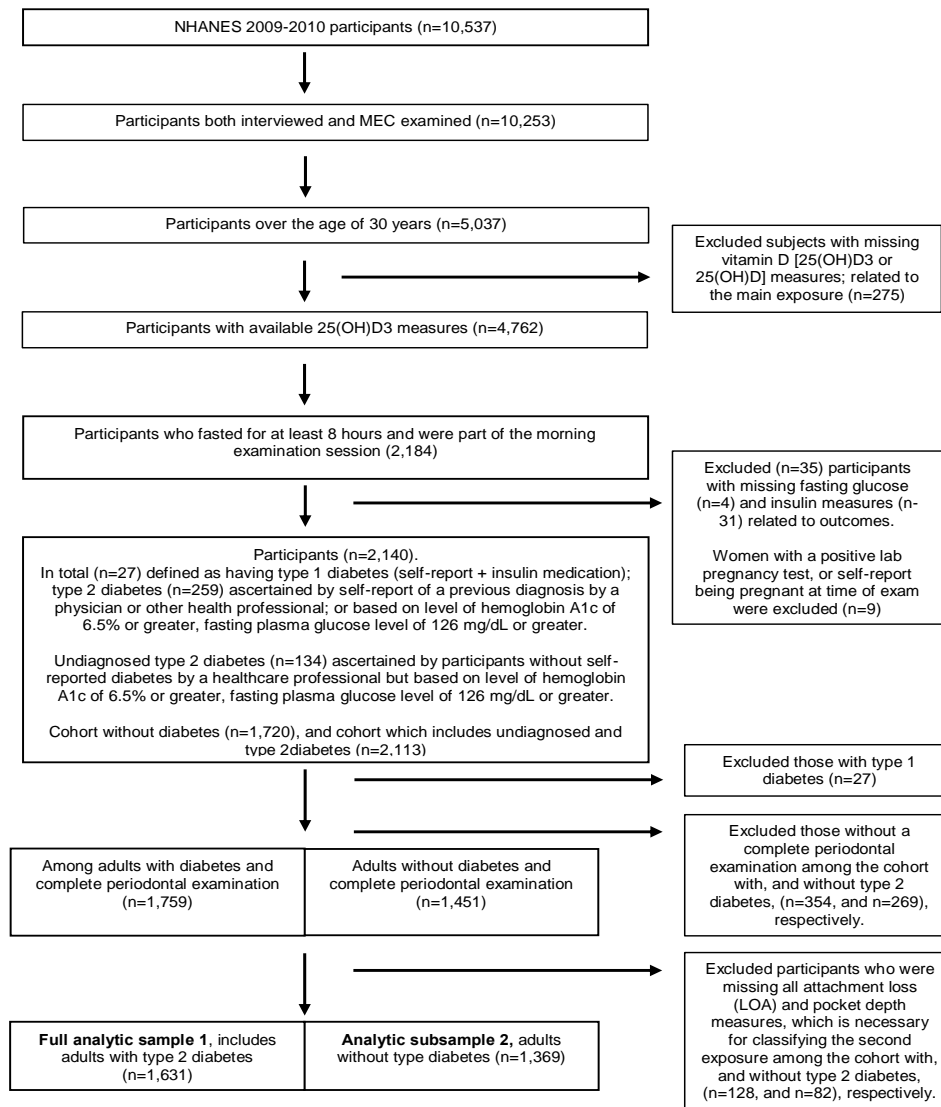


SUPPLEMENTARY Figure S1: Flow diagram of inclusion and exclusions criteria for both analytical samples from the National Health and Nutritional Examination Survey (NHANES) 2009-2010



SUPPLEMENTARY Table S1: Participant characteristics of adult participants over 30 years of age by prediabetes from the National Health and Nutritional Examination Survey (NHANES) 2009-2010*

Characteristics	Analytic subsample 2					
	Prediabetes §					
	Total		Present		Absent	
	N	%	N	%	N	%
Unweighted sample	1369	87.43	817	54.92	552	45.08
Weighted sample	118 980 564		65 340 787		53 639 777	
Age categories (%)						
Age ≥ 30 to < 45 years (R)	530	41.2	245	32.1	285	52.4
Age ≥ 45 and < 65 years	584	44.0	376	48.0	208	39.1
Age ≥ 65 years	255	14.8	196	20.0	59	8.50
Sex (%)						
Male (R)	637	47.3	443	55.5	194	37.4
Female	732	52.7	374	44.5	358	62.6
Race/ethnicity (%)						
Non-Hispanic white (R)	664	70.3	375	67.3	289	74.0
Non-Hispanic Black	223	10.5	150	12.2	73	8.4
Total Hispanic including multiracial	482	19.2	292	20.5	190	17.7
Education (%)						
Some College or higher (R)	716	62.2	390	56.6	326	69.0
High school diploma	301	22.1	188	24.6	113	19.1
Less than high school	348	15.7	236	18.8	112	12.0
Health Insurance (%)						
Yes (R)	1010	80.7	588	78.4	422	83.5
No	359	19.3	229	21.6	130	16.5
Poverty income ratio, PIR (%)						
PIR ≥ 350% = PIR ≥ 3.50 (R)	419	44.3	235	41.9	184	47.2
130% ≤ PIR < 350% = 1.30 ≤ PIR < 3.50	452	32.8	263	32.1	189	33.7
PIR < 130% = PIR < 1.30	373	15.9	240	17.8	133	13.6
Did not answer (missing)	125	7.0	79	8.2	46	5.5
Body mass index, BMI categories (%)						
Normal BMI < 25 kg/m ² (R)	370	30.1	165	21.3	205	40.7
Overweight BMI ≥ 25 to <30 kg/m ²	506	35.5	305	36.8	201	34.0
Obese BMI ≥ 30 kg/m ²	488	34.4	343	41.9	145	25.4
Physical activity (%)						
Active, vigorous-to-moderate (R)	804	63.9	466	61.5	338	66.9
Sedentary	565	36.1	351	38.5	214	33.1
Smoking status (%)						
Former or never smoker (R)	1114	83.5	651	81.6	463	85.9
Current smoker	255	16.5	166	18.4	89	14.1
Serum vitamin D3 [25(OH)D3] status (%)						
† Sufficient levels (R)	904	72.1	530	70.7	374	73.8
Insufficient levels (<50 nmol/L)	465	27.9	287	29.3	178	26.2
Serum vitamin [25(OH)D] status (%) †						
Sufficient levels (R)	960	76.6	560	73.8	400	80.0

Insufficient levels (<50 nmol/L)	409	23.4	257	26.2	152	20.0
Season of examination (%)						
Summer, May 1st to Oct 3 rd (R)	760	61.1	432	58.8	328	64.0
Winter, Nov 1st to April 30 th	609	38.9	385	41.3	224	36.0
Periodontitis (%) ‡						
None or mild (R)	782	63.6	407	56.7	375	72.1
Moderate or severe	587	36.4	410	43.4	177	27.9

Missing values: education (n=4; 0.14%); BMI (n=5; 0.32%).

* NHANES survey analytic guidelines recommend the relative standard error is not larger than 30%, all estimates for each subgroup were less than 30%.

† Serum vitamin D [25(OH)D], and vitamin D3 [25(OH)D3] insufficiency is defined as levels (< 50 nmol/L or < 20 ng/ml).

‡ Case Definitions for Periodontitis based on the definition from the Division of Oral Health at the Centers for Disease Control and Prevention (CDC), in collaboration with the American Academy of Periodontology (AAP).

§ Prediabetes based on level of hemoglobin A1c (HbA1c) of 5.7-6.4% (39 to 47 mmol/mol), fasting plasma glucose level of 100-125 mg/dL or adults who reported having been told by a health professional that they have any of the following: prediabetes, impaired fasting glucose, impaired glucose tolerance, or borderline diabetes. Prediabetes excluded those with diagnosed and undiagnosed type 2 diabetes.

25(OH)D, 25-hydroxyvitamin D; 25(OH)D3, 25-hydroxyvitamin D3; BMI, body mass index; PIR, poverty income ratio; R, reference category.

SUPPLEMENTARY Table S3: Logistic regression models assessing the joint effect of serum vitamin D3 [25(OH)D3] concentrations and periodontitis with HOMA-IR, prediabetes, and type 2 diabetes among overweight and/or obese adults over 30 years of age from the National Health and Nutritional Examination Survey (NHANES) 2009-2010

Outcomes		HOMA-IR*		Prediabetes†		Type 2 diabetes‡		
Exposures		With/without outcome§ (n)	Odds Ratio; (95% CI)	With/without outcome§ (n)	Odds Ratio; (95% CI)	With/without outcome§ (n)	Odds Ratio; (95% CI)	
G = 0 (periodontitis none or mild)	E = 0 [25(OH)D3] sufficiency	105/254	reference (1.00)	213/146	reference (1.00)	40/359	reference (1.00)	
	E = 1 [25(OH)D3] insufficiency¶	77/136	1.25; (0.86, 1.82)	124/89	0.77; (0.47, 1.25)	39/213	1.21; (0.55, 2.68)	
	G = 1 (periodontitis moderate or severe) ††	E = 0 [25(OH)D3] sufficiency	82/184	1.01; (0.63, 1.61)	193/73	1.04; (0.52, 2.07)	72/266	1.29; (0.72, 2.31)
		E = 1 [25(OH)D3] insufficiency¶	60/96	1.51; (0.95, 2.42)	118/38	1.24; (0.61, 2.53)	75/156	2.95; (1.40, 6.19) **
P value ‡‡			0.55		0.30		0.14	
		With/without outcome§§ (n)		With/without outcome§§ (n)		With/without outcome§§ (n)		
G = 0 (periodontitis none or mild)	E = 0 [25(OH)D3] sufficiency	105/254	reference (1.00)	213/146	reference (1.00)	40/359	reference (1.00)	
	E = 1 [25(OH)D3] insufficiency¶	77/136	1.28; (0.90, 1.84)	124/89	0.79; (0.50, 1.28)	39/213	1.22; (0.56, 2.64)	
	G = 1 (periodontitis moderate or severe) ††	E = 0 [25(OH)D3] sufficiency	82/184	1.04; (0.61, 1.78)	193/73	0.97; (0.48, 1.92)	72/266	1.34; (0.75, 2.41)
		E = 1 [25(OH)D3] insufficiency¶	60/96	1.50; (0.89, 2.54)	118/38	1.13; (0.56, 2.28)	75/156	3.16; (1.59, 6.27) **
P value ‡‡			0.68		0.36		0.13	

* Homeostatic model assessment of insulin resistance (HOMA-IR) ≥ 4.17 (population specific 75th percentile) established using fasting glucose and insulin levels by the following formula: $HOMA-IR = [glucose (mmol/L) * insulin (\mu U/mL) / 22.5]$. HOMA-IR, excluded those with diagnosed and undiagnosed type 2 diabetes.

† Prediabetes based on level of hemoglobin A1c (HbA1c) of 5.7- 6.4% (39-47 mmol/mol), fasting plasma glucose level of 100-125 mg/dL or adults who reported having been told by a health professional that they have any of the following: prediabetes, impaired fasting glucose, impaired glucose tolerance, or borderline diabetes. Prediabetes excluded those with diagnosed and undiagnosed type 2 diabetes.

‡ Type 2 diabetes based on self-report of a previous diagnosis by a physician or other health professional; or based on level of hemoglobin A1c of (HbA1c) of 6.5% (48 mmol/mol) or greater, fasting plasma glucose level of 126 mg/dL or greater.

§ Minimally adjusted model for age, sex, race/ethnicity, PIR, season, smoking, physical activity.

¶ Serum vitamin D3 [25(OH)D3] insufficiency defined as levels (< 50 nmol/L or < 20 ng/ml).

** Significance ($p < 0.05$). Statistically significant values are shown in bold.

†† Case Definitions for Periodontitis based on the definition from the Division of Oral Health at the Centers for Disease Control and Prevention (CDC), in collaboration with the American Academy of Periodontology (AAP).

‡‡ Represents multiplicative interaction p value results from adjusted survey logistic models

§§ Fully adjusted model for age, sex, race/ethnicity, education, insurance, season, smoking, physical activity, body mass index.

SUPPLEMENTARY Table S4: Logistic regression models assessing the joint effect of serum vitamin D [25(OH)D] concentrations and periodontitis with HOMA-IR, prediabetes, and type 2 diabetes among overweight and/or obese adults over 30 years of age from the National Health and Nutritional Examination Survey (NHANES) 2009-2010

Outcomes		HOMA-IR*		Prediabetes†		Type 2 diabetes‡	
Exposures		With/without outcome§ (n)	Odds Ratio; (95% CI)	With/without outcome§ (n)	Odds Ratio; (95% CI)	With/without outcome§ (n)	Odds Ratio; (95% CI)
G = 0 (periodontitis none or mild)	E = 0 [25(OH)D] sufficiency	116/269	reference (1.00)	228/157	reference (1.00)	47/385	reference (1.00)
	E = 1 [25(OH)D] insufficiency¶	66/121	1.08; (0.65, 1.82)	109/78	0.97; (0.58, 1.64)	32/187	0.94; (0.38, 2.34)
G = 1 (periodontitis moderate or severe) ††	E = 0 [25(OH)D] sufficiency	88/192	0.93; (0.60, 1.45)	202/78	1.04; (0.53, 2.02)	91/280	1.47; (0.84, 2.57)
	E = 1 [25(OH)D] insufficiency¶	54/88	1.57; (0.89, 2.77)	109/33	1.74; (0.92, 3.32)	56/142	2.05; (1.05, 4.03) **
P value ‡‡			0.17		0.19		0.46
		With/without outcome§§ (n)		With/without outcome§§ (n)		With/without outcome§§ (n)	
G = 0 (periodontitis none or mild)	E = 0 [25(OH)D] sufficiency	116/269	reference (1.0)	228/157	reference (1.00)	47/385	reference (1.00)
	E = 1 [25(OH)D] insufficiency¶	66/121	1.12; (0.68, 1.85)	109/78	1.01; (0.60, 1.71)	32/187	0.97; (0.40, 2.37)
G = 1 (periodontitis moderate or severe) ††	E = 0 [25(OH)D] sufficiency	88/192	0.96; (0.58, 1.60)	202/78	0.97; (0.50, 1.88)	91/280	1.53; (0.89, 2.62)
	E = 1 [25(OH)D] insufficiency¶	54/88	1.56; (0.84, 2.92)	109/33	1.58; (0.84, 2.99)	56/142	2.29; (1.27, 4.12) **
P value ‡‡			0.24		0.25		0.41

* Homeostatic model assessment of insulin resistance (HOMA-IR) ≥ 4.17 (population specific 75th percentile) established using fasting glucose and insulin levels by the following formula: $HOMA-IR = [glucose (mmol/L) * insulin (\mu U/mL) / 22.5]$. HOMA-IR, excluded those with diagnosed and undiagnosed type 2 diabetes.

† Prediabetes based on level of hemoglobin A1c (HbA1c) of 5.7- 6.4% (39-47 mmol/mol), fasting plasma glucose level of 100-125 mg/dL or adults who reported having been told by a health professional that they have any of the following: prediabetes, impaired fasting glucose, impaired glucose tolerance, or borderline diabetes. Prediabetes excluded those with diagnosed and undiagnosed type 2 diabetes.

‡ Type 2 diabetes based on self-report of a previous diagnosis by a physician or other health professional; or based on level of hemoglobin A1c (HbA1c) of 6.5% (48 mmol/mol) or greater, fasting plasma glucose level of 126 mg/dL or greater.

§ Minimally adjusted model for age, sex, race/ethnicity, PIR, season, smoking, physical activity.

¶ Serum vitamin D [25(OH)D] insufficiency defined as levels (< 50 nmol/L or < 20 ng/ml).

** Significance ($p < 0.05$). Statistically significant values are shown in bold.

†† Case Definitions for Periodontitis based on the definition from the Division of Oral Health at the Centers for Disease Control and Prevention (CDC), in collaboration with the American Academy of Periodontology (AAP).

‡‡ Represents multiplicative interaction p value results from adjusted survey logistic models

§§ Fully adjusted model for age, sex, race/ethnicity, education, insurance, season, smoking, physical activity, body mass index.

SUPPLEMENTARY Table S5: Additive interaction measures derived from odds ratios between vitamin D [25(OH)D3], [25(OH)D], and periodontitis on type 2 diabetes among adults ≥ 30 years of age from the National Health and Nutritional Examination Survey (NHANES) 2009-2010

Outcome	Type 2 diabetes †						
	Additive measures of interaction *	Vitamin D3 [25(OH)D3] ‡			RERI	Vitamin D [25(OH)D] ‡	
		95% Confidence Interval (CI)				95% Confidence Interval (CI)	
		Lower	Upper		Lower	Upper	
Relative Excess Risk due to Interaction (RERI)	1.49 **	0.07	2.91	0.68	-0.54	1.90	
Attributable proportion (AP)	0.53 **	0.19	0.86	0.34	-0.19	0.88	

* Estimating measures of interaction on the additive scale for vitamin D insufficiency and periodontitis (case definitions for periodontitis based on the definition from the Division of Oral Health at the Centers for Disease Control and Prevention, in collaboration with the American Academy of Periodontology), reference group mild-to-no periodontitis. Relative Excess Risk due to Interaction, RERI = (OR11 - OR10 - OR01 + 1); and Attributable proportion, AP = (OR11 - OR10 - OR01 + 1)/OR11 were derived from previously shown odds ratios (ORs) point estimates from fully adjusted survey logistic procedures with appropriate sample weights and survey design variables.

† Type 2 diabetes based on self-report of a previous diagnosis by a physician or other health professional; or based on level of hemoglobin A1c of (HbA1c) of 6.5% (48 mmol/mol) or greater, fasting plasma glucose level of 126 mg/dL or greater.

‡ Serum vitamin D [25(OH)D], and vitamin D3 [25(OH)D3] insufficiency defined as levels (< 50 nmol/L or < 20 ng/mL). Reference group for vitamin D [25(OH)D], and vitamin D3 [25(OH)D3] sufficiency are levels (≥50 nmol/L or 20 ng/mL).

**Significance at p<0.05. Statistically significant values are shown in bold.