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Short Communication

Lycopene, Race and Periodontitis: Disparities in Older Adults

Katherine Kwong [a], You Lu [b], ZhuoHuan Li [c], Susu Luo [d,h], Zhaoyu Huang [e], Zhong Chen [f], Na Zhao [e,*], Tung-Sung Tseng [g,*]

[a] Department of Human Development, Connecticut College, New London, CT, United States of America
[b] Section of Endocrinology and Metabolism, Deming Department of Medicine, Tulane University, New Orleans, LA, United States of America
[c] Department of Biostatistics, Tulane University, New Orleans, LA, United States of America
[d] Moores Cancer Center, School of Medicine, University of California San Diego, CA, United States of America
[e] Key Laboratory in Software Engineering of Yunnan Province, School of Software, Yunnan University, Kunming, China
[f] School of Computing, Southern Illinois University, Carbondale, IL, United States of America
[g] Community Health Science and Policy, School of Public Health, Louisiana State University Health Science Center, New Orleans, LA, United States of America
[h] The Third Department of Hepatic Surgery, Shanghai Eastern Hepatobiliary Surgery Hospital, Shanghai, China

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ABSTRACT

Background: Periodontitis is a severe gum disease that can be an indicator of other health conditions such as cardiovascular disease and diabetes. Lycopene has been suggested as an adjunct therapy for periodontitis. This study aims to investigate the association between insufficient lycopene intake and the risk of Periodontitis among non-Hispanic White (NHW) and non-Hispanic Black (NHB) older adults.
Methods: The study included 1,227 adults aged 65–79 years from the National Health and Nutritional Examination Survey (2009–2014). Total lycopene intake from daily diet was studied with age, race, marital status, smoking status, BMI, diabetes, sex, and education as independent variables in regression model.
Results: Overall, 48.7% of the older adults exhibited varying degrees of PD, and 49.1% had insufficient dietary lycopene intake. Adequate lycopene intake was associated with a reduced likelihood of severe PD (odds ratio (O.R.): 0.33; 95%CI: 0.17−0.65). NHBs were more prone to developing severe PD compared to NHWs (O.R.: 2.82, 95%CI: 1.46−5.45). Women exhibiting a lower likelihood of severe PD than men (O.R.: 0.27; 95% CI: 0.14−0.55). NHW females, who were less likely to have severe PD compared to NHW males (O.R.: 0.26; 95% CI: 0.12−0.56).
Conclusion: Dietary lycopene intake is associated with reduced risk of severe PD, particularly in NHW individuals over 65 years old. PD was more common in men and NHB individuals, with a latter group showing a higher prevalence of severe PD. Our results suggest that future PD prevention strategies should consider targeted, race- and sex-specific dietary interventions.

1. Introduction

Periodontitis (PD), as one type of periodontal disease it affects over 70% of United States adults age over 65 years old [1]. Previous studies observed racial disparity of PD in non-Hispanic White (NHW) and non-Hispanic Black (NHB) adults with an indication that PD is a risk factor for other chronic, and potentially more serious health conditions resulting in more than just edentulism [2–6]. While non-modifiable factors like age, sex, and race influence PD disparities, dietary lycopene intake, a non-provitamin alpha-carotenoid, presents a modifiable preventative measure. Studies have established a significant correlation between lycopene as an adjunct to professional dental cleanings and PD [7–9]. In this study, we aim to explore the association of dietary lycopene intake and risk of severe PD in minority older adults.

2. Methods

Three consecutive two-year survey cycle datasets (2009–2014) were

Abbreviations: PD, periodontitis; NHANES, National Health and Nutrition Examination Survey; MEC, mobile examination center; NHB, non-Hispanic Black; NHW, non-Hispanic White; AMPM, Automated Multiple Pass Method; ANOVA, Analysis of Variance; CDC, Centers for Disease Control and Prevention; OR, Odds Ratio; CI, Confidence Interval; BMI, Body-Mass-Index; ACA, Affordable Care Act; SEM, Standard Error of the Mean; Sev, Severe.

* Corresponding authors.
E-mail addresses: zhaonayx@126.com (N. Zhao), ttseng@lsuhsc.edu (T.-S. Tseng).

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combined and extracted from the U.S. Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES) dataset. The study included 1,227 adults aged 65–79 years with complete responses on lycopene intake and oral health records. Lycopene consumption was determined using a two-day dietary interview questionnaire assessing total intake based on participant recall. NHANES employs a multistage, stratified, probability-cluster sampling method under the supervision of the National Center for Health Statistics of the CDC) [10]. Trained staff conducted in-person, face-to-face interviews with qualified participants in their homes. Oral health examinations were performed in a mobile examination center (MEC). Individual demographic and health-related information was collected through examination. The National Center for Health Statistics Research Ethics Review Board revised and approved the survey protocol [11]. All participants signed a paper-based informed consent form.

3. Measurements

The main exposure of interest for this work was lycopene intake and PD status was the primary outcome. We defined lycopene intake cut-off level as ≥8000mcg as sufficient and <8000 mcg as insufficient from daily food [12]. Three levels of PD, severe, mild, and moderate are defined as by following the reference [13]. Given that mild PD prevalence did not consistently increase with age [13], mild and moderate PD groups were combined into a single non-severe PD group and compared to the severe PD group. Other social demographic variables, i.e. age, race, sex, are also considered with education, smoking status [14], marital status [15]. and body mass index [16] in this study.

4. Statistical analysis

Descriptive statistics were used to summarize participant demographics, lycopene intake, smoking status, and clinical characteristics based on PD status (severe to none). The associations between these factors and PD status were tested using the Rao-Scott Chi-square test for categorical variables and Fisher's exact test for small samples. A one-way Analysis of Variance test was used to examine differences in continuous variables. All analyses were performed in R (3.6.3) using the "survey" package [17]. Survey-weighted multinomial logistic regression models included age, sex, race, smoking status, and education as covariates. Multicollinearity was absent in all variables. All tests were two-sided, and statistical significance was defined as a p-value <0.05.

5. Results

The study included a total of 1,227 NHW and NHB older adults aged 65–79 years from NHANES 2009−2014. Table 1 presents the weighted percentages and raw sample sizes for demographics and lycopene intake by PD level. Overall, 22.1% of participants (n = 246) had sufficient lycopene intake, while 77.9% (n = 981) had insufficient intake. The self-reported daily lycopene intake was 3847 ± 360 mcg for participants with severe PD, 5452 ± 498 mcg for non-severe PD, and 5278 ± 338 mcg for those with no PD (p = .006). The prevalence of all levels of PD was 48.7%. NHB older adults had a higher prevalence of severe and overall PD compared to NHW older adults (12.2% vs 4.86% and 55.6% vs 47.86%, respectively; p = .0004). The mean age of individuals diagnosed with severe PD was 69.9 ± 0.4 years, compared to other groups (p = 0.17). Although NHB individuals constituted only 10.5% of the participants, they accounted for approximately 12.2% of severe PD diagnoses, nearly three times higher than NHW individuals (p = 0.0004). Older adults with sufficient dietary lycopene had fewer diagnoses of severe PD (2.4% vs. 6.5%, respectively, p = 0.04). The severe PD ratio was also high among current smokers (18.8%), four times greater than never and former smokers (4.6% and 4.1%, respectively, p = 0.0001). Additionally, fewer older female adults had severe PD compared to older male adults (3.1% vs. 8.3%, respectively, p = 0.001).

Table 1
Factors associated with different degrees of periodontitis in older adults aged 65 years and older (weighted).

Characteristics	Overall	Severe PD	Non-severe PD	Normal	p-Value
Total, n (%)	1,227	98 (5.6)	531 (43.1)	598 (51.3)	
Mean lycopene intake ± SEM (mcg)	5,273 (318)	3,847 (360)	5,452 (498)	5,278 (338)	0.006
Mean age ± SEM (year)	70.5 (0.1)	69.9 (0.4)	70.6 (0.2)	70.5 (0.2)	0.17
Lycopene intake, n (%)					0.04
Insufficient	981 (77.9)	81 (6.5)	424 (42.6)	476 (50.9)	
Sufficient	246 (22.1)	17 (2.4)	107 (44.7)	122 (52.9)	
Race/ethnicity, n (%)					0.0004
non-Hispanic White	875 (89.5)	51 (4.9)	377 (43.0)	447 (52.1)	
non-Hispanic Black	352 (10.5)	47 (12.2)	154 (43.4)	151 (44.4)	
Education, n (%)					0.14
Less than high school	269 (16.0)	25 (5.5)	98 (35.6)	146 (58.9)	
High school or more	956 (84.0)	73 (5.7)	431 (44.3)	452 (50.0)	
Smoking status, n (%)					0.0001
Never smoker	553 (47.1)	41 (4.6)	233 (43.8)	279 (51.6)	
Former smoker	542 (44.2)	38 (4.1)	253 (44.5)	251 (51.3)	
Current smoker	120 (8.7)	19 (18.8)	42 (34.9)	59 (46.3)	
Sex, n (%)					0.001
Male	624 (48.1)	70 (8.3)	288 (45.3)	266 (46.3)	
Female	603 (51.9)	28 (3.1)	243 (40.9)	332 (56.0)	
Age, n (%)					0.73
65−70	570 (52.9)	51 (6.1)	257 (43.9)	262 (50.0)	
71−79	657 (47.1)	47 (5.1)	274 (42.1)	336 (52.8)	
Marital status, n (%)					0.53
Living with a partner	769 (69.4)	57 (5.5)	330 (42.2)	382 (52.4)	
Living alone	458 (30.6)	41 (6.0)	201 (45.1)	216 (48,9)	
Diabetes Status, n (%)					0.89
Diabetes free	288 (18.2)	19 (6.9)	129 (45.6)	140 (47.5)	
Diabetes	886 (77.2)	75 (5.1)	380 (42.7)	431 (52.2)	
Body mass index, n (%)					0.79
Under/normal weight	340 (29.5)	31 (4.6)	144 (43.8)	165 (48.8)	
Overweight	457 (37.2)	36 (4.8)	200 (43.9)	221 (51.2)	
Obese	423 (33.3)	31 (6.5)	42 (40.0)	59 (53.5)	

Notes: SEM: standard error of the mean; PD: periodontitis.

Overall, lycopene intake, sex, smoking, and race were significant risk factors for PD levels in this study.

The computed results from weighted multinomial logistic regression models are given in Table 2. After adjusting for covariables, participants with sufficient lycopene intake had 0.33 times odds (95% confidence interval (C.I.): 0.17−0.65, p = 0.002) associated with severe PD, compared to older adults who have insufficient lycopene intake. NHB has 2.82 times odds (95% C.I.: 1.46−5.45, p = 0.003) associated with severe PD in comparison to NHW. Female participants have 0.27 times odds of severe PD, compared to male participants (95% C.I.: 0.14−0.55,

Table 2
Factors associated with severe PD and non-severe PD.

	Severe PD			Non-severe PD		
Variables	Adjusted O.R.	95%C.I.	p-Value	Adjusted O.R.	95%C.I.	p-Value
Lycopene intake			0.002			0.90
Insufficient	[Ref]			[Ref]		
Sufficient	0.33	0.17−0.65		0.97	0.64−1.49	
Race/ethnicity						
non-Hispanic White	[Ref]		0.003	[Ref]		0.12
non-Hispanic Black	2.82	1.46−5.45		1.32	0.93−1.87	
Smoking status						
Never smoker	[Ref]			[Ref]		
Former smoker	0.70	0.33−1.48	0.33	0.99	0.63−1.54	0.95
Current smoker	3.29	1.55−6.97	0.002	0.86	0.44−1.70	0.66
Education			0.4			0.09
Less than high school	[Ref.]			[Ref]		
High school or more	1.49	0.58−3.84		1.50	0.93−2.42	
Sex			0.0007			0.09
Male	[Ref]			[Ref]		
Female	0.27	0.14−0.55		0.73	0.50−1.06	
Age						
65−70	[Ref]			[Ref]		
71−79	0.91	0.46−1.82	0.78	0.90	0.57−1.43	0.65

Notes: C.I.: confidence interval; Ref: reference; O.R.: odds ratio.

$p = 0.0007$). Further moderation analysis confirmed race as a moderator between dietary lycopene intake and severe PD ($p < 0.0001$).

Results of stratification analysis between NHW and NHB are given in Table 3. For NHW, female participants have 0.26 times odds (95% C.I.: 0.12−0.56, $p = 0.001$) associated with severe PD compared to males. And NHW participants with sufficient lycopene intake had 0.13 times odds associated with severe PD (95% C.I.: 0.05−0.37, $p < 0.0001$), compared to those with insufficient intake. Such association between severe PD and sex/lycopene intake was not observed in NHB.

6. Discussion

The study population largely consumed insufficient dietary lycopene (77.9%). Along with dietary lycopene, race, sex, and smoking status were risk factors for severe PD, with NHB individuals, men, and current smokers at higher risk. This analysis corroborates existing literature indicating variability in PD between NHB and NHW older adults [5]. NHB women had higher severe PD odds than NHW women, with race moderating lycopene intake and severe PD. Existing research suggests potential biological and social factors contributing to this racial disparity, including genetic predisposition, inflammation, and acid production from sugary food consumption, potentially leading to gum disease [18,19]. Aggressive PD forms have shown familial aggregation within the NHB community, suggesting a genetic predisposition [20]. This analysis reinforces the literature's finding of variability in PD between NHB and NHW older adults [5].

However, this analysis suggests that dietary lycopene intake may also explain the racial disparity in PD development. Lycopene intake is significantly higher in NHW individuals, while severe PD prevalence is lower [21]. NHB older adults' higher PD prevalence may stem from how additional preventative PD measures were determined for this analysis. Prior studies acknowledge racial disparities in oral health but rarely emphasize PD in older adults or analyze modifiable risk factors centered on nutrition instead of preventative dental care or non-modifiable factors [22].

This study also examined sex's impact on PD prevalence. Older females were significantly less likely to have PD than males, with approximately half the likelihood of developing severe or non-severe PD (OR = 0.27 and 0.73). Men are less likely to seek preventative dental care, use tobacco at higher rates, and have hormonal differences [23].

Table 3
Factors associated with PD across different race groups.

	non-Hispanic Black					
	Severe PD			Non-severe PD		
Variables	Adjusted O.R.	95%C.I.	p-Value	Adjusted O.R.	95%C.I.	p-Value
Lycopene intake			0.15			0.41
Insufficient	[Ref]			[Ref]		
Sufficient	2	0.76−5.26		0.73	0.34−1.57	
Sex			0.13			0.87
Male	[Ref]			[Ref]		
Female	0.37	0.11−1.37		0.94	0.44−2.03	
	non-Hispanic White					
	Severe PD			Non-Severe PD		
Variables	Adjusted O.R.	95%C.I.	p-Value	Adjusted O.R.	95%C.I.	p-Value
Lycopene intake			<0.0001			0.95
Insufficient	[Ref]			[Ref]		
Sufficient	0.13	0.05−0.37		1.01	0.69−1.54	
Sex			0.001			0.08
Male	[Ref]			[Ref]		
Female	0.26	0.12−0.56		0.72	0.51−1.03	

Notes: C.I.: confidence interval; Ref: reference; O.R.: odds ratio.

Moreover, race mediated the impact of dietary lycopene intake and PD. Higher lycopene consumption correlated with lower PD likelihood in older adults. However, this study found that insufficient lycopene intake had a higher severe PD odds ratio. Potential explanations include the known irreversibility of PD. Thus, individuals informed of mild PD and the risk of severe PD may act to reduce the risk of developing a more severe form of the disease.

A comprehensive literature review by Leite [24] corroborates that smoking detrimentally affects PD and its progression. Differences in smoking prevalence across U.S. racial groups are well-documented [25]. However, dietary lycopene has shown protective effects against tobacco-promoted changes like non-alcoholic steatohepatitis in animal models [26]. Consequently, although smoking prevalence was 8.7% in this study population, dietary lycopene intake may explain the observed racial and sex disparities in severe PD.

This analysis has limitations. First, while professional oral care and dental insurance can prevent PD and alleviate associated costs, the NHANES dataset does not record dental insurance status [27]. Health insurance status, which NHANES records, cannot indicate dental insurance, as preventative dental insurance is not always included in general health insurance. Additionally, while all participants were over 65 and eligible for Medicare, Medicare rarely covers routine dental cleanings [28]. Older adults can also opt for Marketplace coverage via the Affordable Care Act (ACA) instead of Medicare but must pay a Part A premium. However, ACA treats dental coverage differently based on the enrollee's age. While essential for individuals under 18, dental coverage is not essential for older adults, and Marketplace health plans are not required to offer it [29]. This is a challenge when conducting secondary data analysis with the NHANES dataset. Furthermore, routine professional oral care, a key preventative measure, was not considered due to unavailable data. Although prior studies indicate that preventative dental treatments lower PD risk, this factor was not included here. Numerous external factors, linked to PD prevention by other studies, were not considered in this analysis, possibly impacting PD prevalence and individual dietary lycopene consumption. In addition, the number of individuals with severe PD ($n = 98$), divided into subcategories, was small and this could explain the large confidence intervals and the lack of difference in certain external factors.

Although lycopene intake was calculated as total dietary intake and not by source, this study concludes that there is a relationship between severe PD prevalence and lycopene intake, potentially contributing to the observed racial/ethnic and sex disparities between NHW and NHB older adults and PD. However, this analysis cannot determine whether lycopene consumption and PD differ between food and supplement sources. The distinction between lycopene intake from food versus supplements may affect periodontitis, as prior studies have shown that lycopene could be a useful antioxidant adjunctive treatment for periodontal disease [30]. Certain lycopene-containing foods may impact inflammation and acid production in the oral cavity, possibly affecting gum disease prevalence via increased blood or oral cavity levels. While this study concludes that dietary lycopene intake correlates with severe PD in older adults, it does not determine how the lycopene vehicle impacts PD.

7. Conclusion

This study aimed to explore the association between insufficient lycopene intake and PD risk in NHW and NHB older adults. Overall, insufficient lycopene intake was a risk factor for PD development. While this study could not distinguish between dietary lycopene sources, its conclusions indicate that dietary lycopene intake predicts severe PD in NHW individuals aged 65–79 years. This cross-sectional study's findings suggest that targeted interventions using dietary lycopene as a preventative measure to delay or prevent PD onset should be race and sex specific. However, further longitudinal and/or randomized controlled trials are needed to determine whether the observed correlation between dietary lycopene intake and PD is causal and whether increasing dietary lycopene intake to sufficient levels effectively prevents and slows PD progression.

CRediT authorship contribution statement

K.K. and Y.L. contributed equally to this study. K.K. contributed to the original literature review, the conception and design of this study. Y. L. contributed to the conception, design and database organization of the study. Y.L., Z.C., and ZH.L. performed the statistical analysis in R. ZY.H. performed the statistical analysis in Python. K.K. and T.L. cross-validated this study. T.S.T. and N.Z. supervised this study. All authors contributed to manuscript writing.

Ethics approval and consent to participate

The study used publicly available datasets that meet the federal regulation at 46 CFR 46.102.

Declaration of Generative AI and AI-assisted technologies in the writing process

The author(s) are declaring that no AI or AI-assisted technologies were used in the writing process.

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Data and code availability

Publicly available datasets were analyzed in this study. This data can be found at: https://www.cdc.gov/nchs/nhanes/index.htm. The analysis code will be provided upon request.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

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