Community Dental Health (2024) **41,** 39–43
Received 19 July 2023; Accepted 3 October 2023

doi:10.1922/CDH_00150Mira05

The association between edentulism and progress of multimorbidity over 12 years among older American adults

Rolla Mira, Jonathon T. Newton and Wael Sabbah

Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, United Kingdom

Objectives: To examine the relationship between edentulism and the progress of multimorbidity, and the role of nutritional intake and behaviours among older Americans. ***Methods:*** We used 7 waves (2006-2018) of the Health and Retirement Study, a longitudinal survey of older Americans (number included in analysis 2,224). Edentulism was assessed in 2006 and 2012. Multimorbidity was indicated by 5 self-reported conditions: diabetes, heart conditions, lung diseases, cancer, and stroke. Behavioural factors were smoking, excessive alcohol consumption, physical activity, and body mass index. Nutritional intake was calculated by summing 10 nutrients (Protein, Vitamins C, D, B12, E, Calcium, Zinc, Polyunsaturated fatty acids, Folate and ß- carotene). Multilevel models for analysis of longitudinal data were used to assess the association between change in repeated measures of multimorbidity (between 2006 and 2018) and edentulism (2006) adjusting for nutritional intake, behavioural and socioeconomic factors. ***Results:*** Participants who were edentate in 2006 and 2012 had higher rate-ratios (RR) for change in multimorbidity between 2006 to 2018 (RR: 1.29 and 1.28, respectively). After adjusting for socioeconomic factors, total nutrients and behavioural factors, these RR attenuated to 1.12 (95%CI: 1.06, 1.18) and 1.10 (95%CI: 1.05, 1.16), respectively. Total nutrition was negatively associated with progress of multimorbidity, but after adjusting for socioeconomic and behavioural factors the association became insignificant. Total nutrients rates in 2013 were significantly lower among those who were edentate in 2006 and 2012. ***Conclusion:*** There was a longitudinal association between edentulism and progress of multimorbidity. The relationship appeared to be mediated be behaviours and nutrition.

Keywords*: multimorbidity, Aging, Edentulism, Longitudinal Studies, Nutrient Intake*

Introduction

With the ageing population there is an increase in the number of chronic conditions affecting older adults. Unsurprisingly, multimorbidity has become a significant global health problem (Fortin *et al.*, 2012). Chronic diseases are the most prevalent and costliest health conditions in the US. About 60% of American adults suffer from chronic diseases, and 40% have two or more (Centre for Disease Control and Prevention, 2022). Seven chronic conditions, namely diabetes, chronic kidney disease, chronic lung disease, cancer, stroke, heart disease, and Alzheimer's were identified as the primary causes of death and disability (Centre for Disease Control and Prevention, 2022).

Edentulism is also a global public health concern. One in every six adults aged 65 and older are edentate in the USA (Centre for Disease Control and Prevention, 2022). Half of all American adults between 20 to 64 have lost at least one tooth. Between 2009-2014, 6.2 million Americans aged 50 and older were edentate, with 17.6% and 22.5% among 65+ and 75+ years being edentate, respectively (Dye *et al.*, 2019).

An earlier review associated edentulism with several chronic conditions (Felton, 2016). A recent cross-sectional study demonstrated that tooth loss was associated with multimorbidity among American adults (Hag Mohamed and Sabbah, 2023). Inability to eat associated with tooth loss could influence development and progress of chronic conditions. Tooth loss and edentulism are associated with diet-related chronic diseases such as obesity, malnutrition, cardiovascular disease, and diabetes (Nascimento *et al.*, 2016; Toniazzo *et al.*, 2018)

Other pathways link tooth loss/edentulism to chronic conditions including inflammatory and psychological pathways (Falcao and Bullón, 2019; Kudsi *et al.*, 2020; Raphael, 2017). Tooth loss and multimorbidity relationship could also be attributed to common risk factors, which include behavioural and socioeconomic factors (Gaio *et al.*, 2012; Ren *et al.*, 2017; Xu *et al.*, 2021). In other words, adverse socioeconomic conditions could affect behavioural risk factors which in turn impact both tooth loss and multimorbidity. However, the relationship between tooth loss and multimorbidity is still not fully addressed in the literature (de Medeiros *et al.*, 2022; Gaio *et al.*, 2012).

Given the potential role of edentulism in the progress of multimorbidity, and the lack of longitudinal studies of this relationship, this study aims to test if there is a longitudinal association between edentulism in 2006 and 2012 and progress of multimorbidity from 2006 to 2018 among older American adults, and whether nutritional intake and behaviours mediate this relationship.

Method

We used longitudinal data from the Health and Retirement Study (HRS). This survey collected data biennially

Correspondence to: Dr. Rolla Mira Email: Rolla.Mira@kcl.ac.uk

starting in 1992 with response rates consistently over 80% and included more than 43,559 individuals from 1992 to 2018. The sample included Americans adults aged 50 years and older (Sonnega *et al.*, 2014). Before each interview, participants received study information by mail, receive a confidentiality statement and provide oral consent immediately before each interview. Ethical approval is not required for this paper because HRS data are publicly available. The oral health question was introduced in 2006, thus the current analysis included data from 2006 to 2018. Inclusion criteria included those aged 50 and over, who answered the oral health question and participated in the nutritional module (in 2013) and physical examinations. Participants with missing data for any of the included variables in each wave were excluded from the analysis.

Oral health was measured in waves 8 (2006), 11 (2012) and 14 (2018). Edentulism was indicated by answering "yes" to the question "Have you lost all your upper and lower natural permanent teeth?". In this analysis we used edentulism from wave 8 (2006), then from wave 11 (2012). We did not include edentulism from 2018 as it would not reflect a longitudinal association with change in multimorbidity up to 2018.

Multimorbidity was indicated by 5 self-reported chronic conditions: diabetes, heart conditions, lung diseases, cancer, and stroke. These conditions were selected because they are common among older adults and are classified as major causes of disability and death in the US (Centre for Disease Control and Prevention, 2022). The number of these conditions was summed in each wave to create a variable of multimorbidity ranging from 0 to 5. Participants with 5 chronic conditions at baseline (2006) were excluded from the analysis as they would not show any increase.

Demographic variables were gender (female/male), age (used as continuous variable), marital status (Married, unmarried/divorced, and widowed) and race/ethnicity (White American, Black/African American, Hispanic, and other). Socioeconomic position (SEP) was indicated by education (<high school, high school, some college, and college and above), total wealth and poverty-income ratio. Wealth measures were calculated as the sum of the appropriate wealth components less debt. Wealth was categorised into quartiles (highest, second highest, second lowest, and lowest). The poverty-income ratio (ratio of household income from the last calendar year to the U.S. Census poverty thresholds) was also categorised into quartiles (referred to as income). Behavioural variables were physical activity, smoking (never, former, and current smoker), and alcohol consumption (no/moderate, and excessive consumption).

Physical activity (PA) was reported in three categories according to intensity: light, moderate, and vigorous. Light PA included walking, dancing, and bowling. Moderate activities included gardening, cleaning the car, walking at a moderate pace, and stretching exercises. Aerobics, running and swimming were categorised as vigorous activity. The following scores were assigned for each category: Frequency of mild activity per day was coded as: 3+ times/week = 1, 1-2 times/week = 0.43, 1-2 times/month = 0.14, <1/month = 0.07, never =0. Moderate and vigorous activities per day were coded in the same way and multiplied by 2 and 3, respectively. The total values of mild, moderate, and vigorous activities were added up to create a scale of physical activities (continuous variable).

Alcohol consumption was based on the number of drinks per day. According to the Dietary Guidelines for Americans, more than 2 drinks per day for men and more than one drink for women are considered excessive alcohol consumption (Dietary Guidlines for Americans, 2022). A new variable indicating excessive alcohol consumption (>2 for men, and >1 for women) was created.

Body mass index (BMI) was used as continuous variable as originally reported in HRS.

Individual nutritional intake was calculated in 2013 according to the values of the Nutrients Recommendations: Dietary Reference Intake (DRI). Ten of 13 nutrients of US Food and Drug Administration were chosen, Protein, Vitamin C, Vitamin D, Vitamin B12, Vitamin E, Calcium, Zinc, Polyunsaturated fatty acids, Folate and ß- carotene. These nutrients were calculated based on DRI (National Institutes of Health) as the following: Protein (men <56 g/day; women <46 g/day), Vitamin C (men 90 mg/day; women 75 mg/day), Vitamin D, HRS calculated vitamin D, in International Units which contradict with the US Food and drug administration as they calculated in microgram MCG, and there are two measures for vitamin D according to age, (both 50–70 years, 15 µg/day; both >70 years, 20 µg/day). Based on this, a convertor was used to measure the values, yielding 15 IU= 600 and 20 IU= 800.Vitamin B12 (<2.4 µg/day). Vitamin E (15 mg/day). Zinc (men <11 mg/day; women <8 mg/day). Polyunsaturated fatty acids (men 160 mg, women 90 mg). Folate (<400 µg/day), and ß- carotene (3 mg). Each nutrient was coded as 0= inadequate intake or 1= adequate intake and summed to one variable (range 0 to 10).

Data from all included seven waves on multimorbidity, wealth, income, marital status, and all behaviours were included in the analysis (time variant variables). Data on gender, ethnicity, education, edentulism and nutrition were time constant. The relationship between edentulism and multimorbidity was tested in a two-level general linear model Poisson family, with repeated observations (level 1) nested within participants (level 2) (Wu and Little, 2011). Survey waves were used as the time indicator.

To test the mediating role of nutrition we followed Van der Weele (2014) 4-Way Decomposition testing (1) association without the mediator, (2) association with mediator, (3) interaction between mediator and main exposure, (4) association between main exposure and mediator. Two sets of Multilevel models were constructed (Kwok *et al.*, 2008). Model 1 adjusted for edentulism in 2006 and demographic factors. Model 2 additionally adjusted for SEP indicators and race/ethnicity. Model 3 was adjusted for behavioural factors, total nutrients and BMI**.** Similar models were conducted using edentulism in 2012 instead of 2006. Finally, we examined the interaction between edentulism and time (survey waves, a continuous variable) to test whether the association between edentulism and multimorbidity changes over time. We also examined the interaction between tooth loss and nutrition. Another Multilevel model was constructed to test the relationship between edentulism (exposure) and total nutrition (outcome) and was adjusted for age

and gender. We also examined the association between nutrition (exposure in 2013) and change in multimorbidity up to 2018 only adjusting for age and gender.

All included variables were time-variant (repeated measures of the same individuals over time) except for gender, race/ethnicity, education, total nutrition and edentulism. All analyses were conducted using Stata 14.2.

Results

Characteristics of participants in each wave are reported in Table 1. At baseline (2006), mean age was 65.8, the mean number of chronic conditions was 0.56 and 13.38% were dentate. Socioeconomic and demographic characteristics were similar in those included in the and those excluded due to missing values.

Table 2 shows the longitudinal association between edentulism in year 2006 and progress of multimorbidity over time, with the contribution of individual behaviours and nutritional intake in this relationship. After adjusting for behavioural factors, total nutrients, and BMI, the IRR for multimorbidity among edentate individuals was 1.12 (95%CI 1.06, 1.18). The IRR for interaction between being edentate in 2006 and the time variable (survey waves) was 1.08 (95%CI: 1.06, 1.10), indicating an increase in the association between being edentate in 2006 and multimorbidity over time. Total nutrition predicted progress of multimorbidity when adjusting for age and gender. However, in the fully adjusted model total nutrition did not predict progress of multimorbidity. There was an interaction between being edentate in 2006 and nutrition with IRR 1.02 (95%CI: 1.01, 1.03).

A similar analysis conducted of the relationship between edentulism in 2012 and multimorbidity showed similar associations. After adjusting for behavioural factors, total nutrients, and BMI, IRR was attenuated to 1.10 (95%CI 1.05, 1.16). Other variables associated with progress of multimorbidity included lower education, lower income, lower wealth, smoking, being physically inactive and higher BMI.

In analysis of the longitudinal association between edentulism (in 2006 and 2012) and total nutrition (2013) adjusting for age and gender, total nutrients in 2013 were lower among those who were edentate in 2006 [IRR 0.97 (95%CI 0.95, 0.99)] and in 2012 [IRR 0.98 (95% CI 0.96, 0.99)]

Discussion

This analysis of a longitudinal data of US older adults demonstrated an association between edentulism and progress of multimorbidity over 12 years. Nutrition appeared to mediate that relationship. However, the association between edentulism and multimorbidity was not completely explained after accounting for behavioural and socioeconomic factors. These findings suggest that edentulism could be a neglected and potential risk factor for progress of multimorbidity and are important as multimorbidity represents an increasingly challenging problem for global healthcare systems.

Research on the oral health/general health relationship has concentrated on a single condition such as cancer, hypertension, and diabetes and its link with tooth loss (Felton, 2016; Nascimento *et al.*, 2016; Toniazzo *et al.*, 2018). However, many older adults suffer from several chronic conditions simultaneously. While some studies assessed the relationship between multimorbidity as an exposure and tooth loss as an outcome (Bomfim *et al.*, 2021), only one US study demonstrated a similar association to the current analysis between edentulism as an exposure and multimorbidity using cross-sectional data (Hag Mohamed and Sabbah, 2023). No other known study has used longitudinal data to assess the relationship between tooth loss and the progress of multimorbidity. That aside, other studies have demonstrated relationships between tooth loss/ edentulism and individual chronic conditions, mortality, and frailty (Felton, 2016; Hakeem *et al.*, 2020; Nascimento *et al.*, 2016; Toniazzo *et al.*, 2018). The current study has the advantage of examining this relationship with multiple conditions using longitudinal data.

The association between edentulism and progress of multimorbidity observed here is important given the ageing population and the continuous increase in multimorbidity and associated cost and burden to the healthcare system (Centre for Disease Control and Prevention, 2022). Furthermore, edentulism is also a public health problem associated with old age that appears to impact multimorbidity (Centre for Disease Control and Prevention, 2022; Felton, 2016).

Several studies have postulated pathways that may have a role in this relationship. Edentulism may affect the ability to chew and intake essential nutrients. Edentate individuals are likely to change their diets from

Table 1. Characteristics of participants 2006-2018.

	Year (Wave)						
	2006 (8) (N= 2,175)	*2008 (9) (N= 2,139)*	*2010 (10) (N= 2,224)*	*2012 (11) (N= 2,145)*	*2014 (12) (N= 2,209)*	*2016 (13) (N= 1,691)*	*2018 (14) (N= 1,522)*
Multimorbidity 'Mean' (95%CI)	0.56 (0.53, 0.59)	0.66 (0.63, 0.70)	0.73 (0.70, 0.77)	0.87 (0.83, 0.91)	0.92 (0.88, 0.96)	1.05 (0.99, 1.09)	1.04 (0.99, 1.10)
Age at exit Mean (95%CI)	65.86 (65.49, 66.24)	67.80 (67.42, 68.17)	69.51 (69.12, 69.90)	71.38 (71.00, 71.75)	72.62 (72.23, 73.00)	73.98 (73.57, 74.37)	74.80 (74.38, 75.21)
Nutrition Mean (95%CI) *1					4.46 (4.41, 4.51)		
Edentate (%)	13.38			15.10			

Table 2. Multilevel analysis of the association between edentulism and multimorbidity in 2006.

		Model 1	*Model 2*	*Model 3*
		IRR (95%CI)*	*IRR* (95%CI)*	*IRR* (95%CI)*
Age at exit!		1.03 (1.02, 1.03)	1.03 (1.02, 1.03)	1.03 (1.03, 1.03)
Gender		0.78 (0.75, 0.81)	0.76 (0.73, 0.79)	0.79 (0.76, 0.82)
Edentulism2006!		1.29 (1.23, 1.36)	1.16 (1.10, 1.22)	1.12 (1.06, 1.18)
Marital status!	Married (REF)	1	1	1
	Divorced / single	1.11 (1.05, 1.18)	0.97 (0.91, 1.03)	0.98 (0.92, 1.04)
	Widowed	1.00 (0.95, 1.05)	0.91 (0.86, 0.96)	0.91 (0.87, 0.96)
Education	College and above (REF)		1	1
	Some college		1.08 (1.02, 1.15)	1.04 (0.98, 1.10)
	High school		1.07 (1.02, 1.13)	1.02 (0.97, 1.08)
	<high school		1.10 (1.03, 1.17)	1.02 (0.96, 1.09)
Wealth quartiles!	Highest (REF)		1	1
	2nd Highest		1.08 (1.03, 1.14)	1.05 (0.99, 1.11)
	2nd lowest		1.19 (1.12, 1.26)	1.11 (1.05, 1.17)
	lowest		1.43 (1.34, 1.53)	1.29 (1.21, 1.38)
Poverty income ratio quartiles!	Highest (REF)		1	1
	2nd Highest		1.16 (1.10, 1.23)	1.14 (1.08, 1.21)
	2nd lowest		1.12 (1.06, 1.19)	1.10 (1.04, 1.17)
	lowest		1.21 (1.13, 1.30)	1.19 (1.11, 1.28)
Race/Ethnicity	White Americans (REF)		1	1
	Black/African Americans		0.99 (0.93, 1.05)	0.97 (0.91, 1.03)
	Hispanic		0.82 (0.76, 0.89)	0.84 (0.78,0.91)
	Others		1.03 (0.92, 1.17)	1.08 (0.96, 1.21)
Total Nutrition				0.99 (0.98, 1.01)
Smoking!	Never (REF)			1
	Former smokers			1.18 (1.14, 1.23)
	Current smokers			1.29 (1.20, 1.38)
Alcohol Consumption!				0.81 (0.76, 0.87)
Physical Activity!				0.91 (0.89, 0.92)
BMI				1.02 (1.02, 1.02)

* IRR= Incidence Rate Ratio, Coef. (95% CI) = coefficient (95% confidence interval).
a Model 1 was adjusted for demographic factors (age, gender, marital status) and edentulism in 2006.
b Model 2 additionally adjusted for SEP indicators (race/ethnicity, education, wealth, and poverty income ratio).
c Model 3, additionally adjusted for, physical activity, smoking, excessive alcohol consumption, BMI and total nutrients
! time-variant variables (Age, wealth quartiles, poverty income ratio, marital status, behaviour)
time constant variable (edentulism)

fresh fruits and vegetables to a softer diet. Our analysis to some extent supports this pathway as the association between edentulism and multimorbidity attenuated after accounting for nutritional intake. We also showed a negative association between edentulism and total nutrition on the one hand and between total nutritional and multimorbidity on the other.

Other pathways not tested here include inflammatory and psychological pathways. While edentulism could be caused by periodontal diseases, inflammatory markers linked to periodontitis are also linked to chronic conditions (Falcao and Bullón, 2019). That aside, edentulism and tooth loss have a negative impact on individual self-esteem and social interaction which may lead to social isolation, affecting psychological wellbeing and general health (Kudsi *et al.*, 2020). Finally, there are common risk factors for both edentulism and multimorbidity, including stress, unhealthy diet, smoking and alcohol consumption. These factors are all linked to adverse socioeconomic factors (de Medeiros *et al.*, 2022), that could confound the relationship between edentulism and multimorbidity.

Interestingly, the relationship between edentulism and progress of multimorbidity from 2006 up to 2018 persisted after accounting for socioeconomic factors, selected behaviours, and nutrition. This observation highlights the role of other potential contributors to the relationship between edentulism and multimorbidity which include other social, behavioural and environmental factors not included here, inflammatory factors, early life conditions and hereditary factors.

The strengths of this study are in using a large longitudinal dataset of older Americans over 12 years, accounting for several behavioural and socioeconomic factors. Furthermore, we used time variant variables accounting for change in the exposure over time. We also tested the interaction between time and edentulism, demonstrating that the association between edentulism and multimorbidity increases over time. To the best of our knowledge no other study has used longitudinal data to assess the relationship between edentulism and multimorbidity. Based on these results, edentulism could be used as an early marker for multimorbidity, which highlights the importance of including oral health promotion in interventions to tackle multimorbidity. Future research should also use intervention studies to test whether improvement in oral health could preventing multimorbidity among older adults. There are few limitations worth mentioning. The use of self-reported doctor diagnosis of chronic conditions is not as accurate as data from medical records. Relying on self-reported total tooth loss might introduce recall bias or be influenced by social desirability bias. Similarly, behaviours and SEP were also self-reported. Finally, while the longitudinal data could support temporality, it does not support causality.

In conclusion, this analysis highlight edentulisms as a potential risk factor for progress of multimorbidity. Oral health promotion might be included in interventions to reduce multimorbidity among older adults.

Acknowledgments

None

References

Bomfim, R.A., Cascaes, A.M. and de Oliveira, C. (2021): Multimorbidity and tooth loss: the Brazilian National Health Survey, 2019. *BMC Public Health* **21**, 2311.

Centre for Disease Control and Prevention (2022): *About Chronic Diseases*. Available at https://www.cdc.gov/chronicdisease/about/index.htm. Atlanta: CDC.

de Medeiros, T.C.C., Areas, E.S.A., Prates, R.C., Chapple, I. and Steffens, J.P. (2022): Association between tooth loss, chronic conditions, and common risk factors: Results from the 2019 Brazilian Health Survey. *Journal of Periodontology* **93**, 1141-1149.

Dietary Guidlines for Americans (2022): *Dietary Guidelines for Americans, 2020-2025 and Online Materials*. Available at https://www.dietaryguidelines.gov/resources/2020-2025-dietary-guidelines-online-materials. Rockville: Office of Disease Prevention and Health Promotion.

Dye, B.A., Weatherspoon, D.J. and Lopez Mitnik, G. (2019): Tooth loss among older adults according to poverty status in the United States from 1999 through 2004 and 2009 through 2014. *Journal of the American Dental Association* **150**, 9-23.e23.

Falcao, A. and Bullón, P. (2019): A review of the influence of periodontal treatment in systemic diseases. *Periodontology 2000* **79**, 117-128.

Felton, D.A. (2016): Complete Edentulism and Comorbid Diseases: An Update. *Journal of Prosthodontics* **25**, 5-20.

Fortin, M., Stewart, M., Poitras, M.E., Almirall, J. and Maddocks, H. (2012): A systematic review of prevalence studies on multimorbidity: toward a more uniform methodology. *Annals of Family Medicine* **10**, 142-151.

Gaio, E.J., Haas, A.N., Carrard, V.C., Oppermann, R.V., Albandar, J. and Susin, C. (2012): Oral health status in elders from South Brazil: a population-based study. *Gerodontology* **29**, 214-223.

Hag Mohamed, S. and Sabbah, W. (2023): Is tooth loss associated with multiple chronic conditions? *Acta Odontologica Scandinavica*, 1-6.

Hakeem, F.F., Bernabé, E. and Sabbah, W. (2020): Association Between Oral Health and Frailty Among American Older Adults. *Journal of the American Medical Directors Association*.

Kudsi, Z., Fenlon, M.R., Johal, A. and Baysan, A. (2020): Assessment of Psychological Disturbance in Patients with Tooth Loss: A Systematic Review of Assessment Tools. *Journal of Prosthodontics* **29**, 193-200.

Kwok, O.M., Underhill, A.T., Berry, J.W., Luo, W., Elliott, T.R. and Yoon, M. (2008): Analyzing Longitudinal Data with Multilevel Models: An Example with Individuals Living with Lower Extremity Intra-articular Fractures. *Rehabilitation Psychology* **53**, 370-386.

Nascimento, G.G., Leite, F.R., Conceição, D.A., Ferrúa, C.P., Singh, A. and Demarco, F.F. (2016): Is there a relationship between obesity and tooth loss and edentulism? A systematic review and meta-analysis. *Obesity Reviews* **17**, 587-598.

National Institutes of Health Nutrient Recommendations: *Dietary Reference Intakes (DRI)*. Available at https://ods.od.nih.gov/HealthInformation/Dietary_Reference_Intakes.aspx. Washington: National Institutes for Health.

Raphael, C. (2017): Oral Health and Aging. *American Journal of Public Health* **107**, S44-S45.

Ren, C., McGrath, C. and Yang, Y. (2017): Edentulism and associated factors among community-dwelling middle-aged and elderly adults in China. *Gerodontology* **34**, 195-207.

Sonnega, A., Faul, J.D., Ofstedal, M.B., Langa, K.M., Phillips, J.W. and Weir, D.R. (2014): Cohort Profile: the Health and Retirement Study (HRS). *International Journal of Epidemiology* **43**, 576-585.

Toniazzo, M.P., Amorim, P.S., Muniz, F. and Weidlich, P. (2018): Relationship of nutritional status and oral health in elderly: Systematic review with meta-analysis. *Clinical Nutrition* **37**, 824-830.

VanderWeele, T.J. (2014): A Unification of Mediation and Interaction: A 4-Way Decomposition. *Epidemiology* **25**, 749-761.

Wu, W. and Little, T.D. (2011): Quantitative Research Methods. In, *Encyclopedia of Adolescence*; eds. Brown, B.B. and Prinstein, M.J. (pp 287-297). San Diego: Academic Press.

Xu, M., Gao, X., Wu, H., Ding, M., Zhang, C., Du, S., Wang, X., Feng, X., Tai, B., Hu, D., Lin, H., Wang, B., Wang, C., Zheng, S., Liu, X., Rong, W., Wang, W., Xu, T. and Si, Y. (2021): Measuring and decomposing socioeconomic-related inequality in the use of oral health services among Chinese adults. *Community Dentistry and Oral Epidemiology* **49**, 47-54.