

Tooth Loss, Cognitive Ability and Socio-Economic Indicators in Older Adults Visiting Day Centers, in Athens and Piraeus, Greece

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Abstract

Background: Interest in ageing populations with limited cognitive ability and poor oral health has increased in recent years.

Objectives: This cross-sectional study aimed to investigate the relationship between cognitive ability, oral health socioeconomic indicators, and tooth loss among a sample of Greek senior adults.

Methods: The study sample included 734 individuals visiting Day Centers for adults age 65 years or older, in two municipalities, Athens and Piraeus, in the Attica area of Greece. Tooth loss was recorded according to WHO criteria, while sociodemographic data and cognitive ability status (Mini Mental State Examination [MMSE] score) were derived through face-to face interviews. Both bivariate and General Linear Model analyses were applied.

Results: The results showed that tooth loss was significantly negatively correlated with the MMSE score, years of education and regular dental attendance, but significantly positively correlated with the age of the participants. There was a gender effect with males losing 2.15 teeth on average more than females.

Conclusions: Cognitive ability (MMSE score), was associated with tooth loss and socioeconomic factors in the studied population. This was the first study in Greece to investigate the effect of cognitive ability on oral health. Further research is needed to examine possible mechanisms affecting cognitive ability associated with oral health inequalities in Greece.

Keywords: Tooth Loss; Cognitive Ability; MMSE; Disparities; Health Inequalities

Introduction

Tooth loss experience is more evident in elders and characterized as an accumulative effect of previous exposure to dental caries, periodontitis, possibly trauma and barriers to dental care [1]. Cognitive ability is also affected by age and found to be associated to edentulism and number of lost teeth [2-7].

Additionally, studies have suggested that oral health is affected by a patient's socioeconomic position in society, especially in older adults [8-15]. Also, general and oral health of senior citizens is also influenced by limited cognitive ability, which is very often in this

vulnerable population group [16-20]. For example, analysis of the National Health and Nutrition Examination Survey (NHANES) studies in the United States revealed that periodontitis was associated with cognitive impairment among older adults [17]. Lower scores of cognitive function have been associated with worse oral health status, and the impact of cognitive function on oral health decreased when there were regular dental visits [18]. One study indicated that uptake of dental care is strongly linked to cognitive functioning with important clinical consequences, but because of the cross-sectional study design, no causal relationship between cognitive function, oral health and utilization have been established [19]. In the NHANES III study, cognitive function partly explained the social gradient in gingival bleeding [20]. Researchers identified the social gradients in oral health, and similarities in the gradients in perceived oral and general health, regarding the prevalence of periodontal and ischemic heart disease [21]; people with poorer cognitive ability had poorer oral health and increased severity of gingival bleeding [20]. In a secondary analysis of the English Longitudinal Study of Ageing, a national prospective cohort study, of community-dwelling people 60 years and over, results showed cognitive and physical decline associated with tooth loss [22]. Secondary analysis data from SHARE study in 14 European countries showed association between oral health and cognitive functioning in middle and later adulthood [23]. In China, the number of missing teeth was significantly associated with severe cognitive impairment [6] and in Korea the results of a cross sectional study revealed that having fewer teeth was a marker of risk for dementia [36]. In Japan, a study examined relationship between tooth loss and cognitive function; severe tooth loss (0 - 10 teeth remaining) found to be significantly associated with poor cognitive function. The number of teeth lost was significantly correlated with age, education level and MMSE score [4].

Interest in ageing populations and social inequalities has increased in recent years. However, the results of both cross-sectional and longitudinal studies are inconsistent. While the results from cross-sectional studies found fading or declining evidence of the social gradient among the oldest groups [24-26], results from longitudinal studies are contradictory, as greater inequalities were found in health in older [27-30]. In other studies, inequalities have been shown to be less obvious in older adults [31-33]; in a longitudinal study of the oral health of older adults in England there was less evidence of influence of a relationship between inequalities and the socioeconomic status [13].

Mamai-Homata, *et al.* (2012) examined tooth loss and oral rehabilitation in Greek adults and found that education level was the only significant predictor of tooth loss in aged groups of 35 - 44 years old and 65 - 74 years old. The mean number of lost teeth was 5.2 in the middle aged and 21.0 in the senior groups, respectively [34].

Demographic ageing is one of the key issues faced by industrialized countries. This segment of the population aged 65 years and over is growing faster than any other age group. The demographic shift towards a 'grey' society is also evident in Greece, as the 65-years and older age group has been significantly increasing in recent years [35-37].

This ageing demographic profile for Greece is due to a combination of factors: (a) reduction in fertility, especially after 1960 (b) increased life expectancy; and (c) migration [38-40]. The Greek population is expected to shift significantly between 2007 and 2050 towards a rapidly ageing population and those aged 65 and over is expected to rise from 25% of the population in 2011 to 32% by 2050 [40]. Therefore, it is necessary to conduct studies investigating the factors affecting general and oral health of this high risk population group, in order improve the quality of life of senior citizens.

This study aimed to assess the influence of cognitive ability (MMSE score) on tooth loss, and explore the role of education, occupation, income and dental attendance on oral health, in an older Greek population aged 65 years or above, visiting Day Centers in two municipalities of Attica region, Greece.

Materials and Methods

The study population comprised of individuals visiting Day Centers (KAPI) for older adults in Greece. Data were collected between February 2014 to January 2015. All individuals participating in the study were Greek citizens living in the Greater Athens area in municipi-

palties of Athens and Piraeus. Athens Municipality has twenty Day Centers and Piraeus has ten, each one in a different neighborhood with a different postal code. The sample was not representative for the whole population; however, clustering methods were employed according to municipalities and Day Centers. People aged 65 years or older, were invited to participate through the municipality to which they belong and the KAPI that they attend. This geographical area-based participant selection method avoids difficulties of a stratified random selection procedure [41]. Response rates obtained in this survey were 80% from Piraeus Day Centers and 77% from Athens area Day centers. Prior to the main study, a pilot study (N = 93) took place in the Greater Athens area in two municipalities, Kallithea (less affluent area) and Philothei (more affluent area). The results helped to estimate the sample size for the main study and to test the procedures and the feasibility of the study. Estimations for the sample size were based on a power of at least 80% (needed to detect the differences in oral health outcomes between socioeconomic groups), at the 5% significant level. The desired sample size was calculated according to the level of probability or uncertainty for the study (significant level 5%). After adjusting the design factor 1.2 for cluster sampling and 20 per cent over sampling for nonresponsive, the final sample size estimated for the study was 734.

Participants were limited to Greeks aged 65 years or older, attendees at Day Centers, who freely volunteered to participate in the study. After successfully completing a pre-test of four simple cognitive screening questions (what is the year, day, place, and time) used as an indicator of the participants ability to communicate and reply accurately and effectively. Individuals who were unable to communicate due to severe vision or hearing impairment were excluded. The social workers and nurses at the Day Centers assisted in communicating and announcing the purpose of the study, ensuring that prospective participants understood. Prospective participants would participate only after understanding the aim of the study and being able to participate of their own free will.

Data were collected through structured, face-to face interviews and clinical examinations. All eligible individuals were interviewed and were clinically examined. The examination procedure was standardized in accordance with World Health Organization (WHO) 1997 guidelines for oral health surveys [42]. There was only one calibrated examiner (P.D.), who also reexamined 10% of participants for intra examiner variability. Calibration procedures took place at the Aristotle's University of Thessaloniki (Dental School) with a senior staff member as the golden standard (Kappa score 0.83). The three interviewers were trained and calibrated by P.D. and the procedure was standardized. To ensure internal consistency reliability and comparability of data, the interviewers were trained and certain rules for asking the questions were applied. All interviewers were familiarized and trained to use the same methodology when applying the questionnaire and instructed not to change the order of the questions. Participants were interviewed only once, for ethical reasons.

In order to ensure privacy, the interviews and dental examinations took place in a private area usually used as an office for the nurse or the physician of the Day Centers. The examiner used a head light, gloves and face masks, and had readily available materials and instruments needed for the study. All clinical data were collected according to WHO (1997) diagnostic criteria and methodology with standard measurements. Self-rated health was classified as excellent, very good, good, fair and poor. Mini Mental State Examination performance score was used as an indicator of cognitive ability and not as a diagnostic tool for dementia. The MMSE test has different parts evaluating orientation to place and time, short and long - term memory, subtraction ability, ability of writing and oral language and the maximum score for this test is 30 [43]. The higher the MMSE score, the better the cognitive ability. The MMSE test has been validated in the Greek population [44,45]. Fountoulakis, *et al.* (2000), found that MMSE score 23/24 as a cut off level for the diagnosis of dementia in Greece, and Solias, *et al.* (2014), proposed the use of the 25th percentile as a more useful cut off score in order to decrease the false positive results.

Socioeconomic measures used for the study were education, occupation, and personal income before taxes. Income was recorded in euro, and recoded into three categories as low, medium and high income. In Greece, minimum wages and salaries are determined by the memorandum. For those over 25 years old, lowest salary is 580 euro. For those under 25 years old, the lowest salary was set at 510.95 euro.

According to Hellenic Statistical Authority, persons at risk of poverty and social exclusion represent 35.6% of the total population. For the year 2016, the at-risk-of-poverty rate for people aged 65 years and over was 13.8% for women and 10.6% for men. The poverty threshold was 4,500 euro (per person) per year and 9,450 euro for households with two adults and two dependent children under 14 years old. The mean annual income of the households of the country was 14,932 euro (income after taxes and social contributors) [46]. In this study personal income was recorded before taxes.

Education was measured as total years of education, as the highest certificate of education received and as an ISCED-97 classification [47].

Occupation classification, was made according to former main occupation and the International Classification of Occupation (ISCO-88 revised in 2008, ISCO-08) [48]. ISCO-08 presents and divides jobs into 436 unit groups. These unit groups are summed and clustered into 130 minor groups, 43 sub-major groups and 10 major groups, based on their similar nature and equivalence in terms of the skill level and skill specialization required for the jobs. The 10 major occupation groups are: managers/professionals/technicians and associate professionals/clerical support workers/service and sales workers/skilled agricultural, forestry and fishery workers/craft and related trade workers/plant and machine operators, and assemblers/elementary occupations/and armed forces. A small percentage of female participants (4, 1%), reported they had never worked. For this small percentage of females, classification was according to the head of household's occupation; this classification for women was previously used by Mackenbach and Kunst (1997) [49]. Thus, for single women who never married, classification was performed according to father's ISCO occupation. For married women occupation classification was according to spouse's ISCO occupation classification. For the present study analysis, the ten occupation groups were merged in four: professionals, service and shop keepers, agriculture and craft workers, and manual workers. The study also explored oral health behaviors: reason for dental visits, frequency of tooth brushing, as confounders. Dryness of the mouth was self-reported by the participant. The participants were asked if they felt xerostomia: "Have you felt any dryness in your mouth during the last six months?"

Ethics

The Ethical Committee of the National and Kapodistrian University of Athens approved the study (18/01/2014). All participants volunteered and only participated after signing consent form. Visits to the KAPI Day Centers were arranged, prior to appointments by telephone or personal communication and after permission from the Municipalities of Athens and Piraeus.

Statistical analyses and measurements

The outcome variable was the number of missing teeth. The statistical analyses were conducted in two stages. First, the potential effect of the MMSE score, gender, personal income, occupation, years of education, brushing frequency, reason for dental attendance, and mouth dryness, on the number of missing teeth was investigated bivariately. T test and Pearson's correlation coefficient were conducted due to the normal distribution of the data. Second, General Linear Model (GLM) was applied to investigate the relationship between the aforementioned predictors and the outcome variables. Significant confounders, as well as interactions were retained in the models. Deviance residuals were calculated in order to evaluate the model's goodness-of-fit. Model assumptions were tested using q-q plots for normality and residual plots versus predicted values or independent variables for homoscedasticity and linearity. Given the nature of the data, all plots were satisfactory not showing severe deviations from the ideal. All reported probability values (p-values) were based on two-sided tests and compared to a significant level of 5%. The analyses of coded data were carried out using SPSS software version 23.0.

Results

The results of this cross-sectional study are shown in tables 1-3. Distribution of the study sample, according to the number of retained and missing teeth by gender, brushing frequency, reason to go to the dentist, mouth dryness, personal income, and occupation is presented in table 1. Also, the distribution of the edentulous population of the study is also provided in table 1. According to independent

samples t test, males and individuals with mouth dryness for more than 6 months, had significantly more missing teeth. Additionally, participants who brushed their teeth or dentures less than once a day, visited the dentist only when they had trouble/pain, had worked as manual workers and with lower income, had also significantly less teeth (GLM analysis, Table 1). Further, the number of missing teeth was significantly negatively correlated with the MMSE score and their years of education, but significantly positively correlated with the age of the participants (Pearson’s r test, table 2).

	Retained Teeth								Missing Teeth*	
	≥ 21		15 - 20		1-14		0 (edentulous)		Mean	Median
	n	%	N	%	n	%	n	%	(sd)	(IR)
Gender										
Male	81	22.9	68	19.2	82	23.2	123	34.7	21.23 (9.86)	22.0 (20.0)
Female	101	26.0	95	24.4	112	28.8	81	20.8	18.94 (9.13)	17.0 (17.0)
*p < 0.001 ^a										
Frequency of brushing teeth or dentures										
Less than once a day	16	19.5	16	19.5	21	25.6	29	35.4	21.67 (9.34)	20.5 (20.0)
Once a day	93	22.1	94	22.4	108	25.7	125	29.8	20.66 (9.51)	20.0 (20.0)
Twice a day	59	31.4	44	23.4	50	26.6	35	18.6	17.93 (9.25)	15.0 (16.0)
More than twice a day	14	26.4	9	17.0	15	28.3	15	28.3	19.96 (10.22)	21.0 (23.0)
*p = 0.004 ^b										
Reason to go to the dentist										
Regular check up	50	48.5	30	29.1	18	17.5	5	4.9	13.31 (7.32)	12.0 (8.0)
Occasionally	36	25.0	34	23.6	36	25.0	38	26.4	19.63 (9.54)	18.0 (21.0)
When in trouble or pain	96	19.4	99	20.0	140	28.2	161	32.5	21.54 (9.36)	22.0 (20.0)
*p < 0.001 ^b										
Dryness in mouth last 6 months										
Yes	67	19.3	79	22.8	94	27.1	107	30.8	20.96 (9.35)	20.0 (20.0)
No	115	29.0	84	21.2	100	25.3	97	24.5	19.22 (9.65)	17.0 (20.0)
*p = 0.013 ^a										
Personal income (euros)										
< 600	53	20.3	55	21.1	77	29.5	76	29.1	21.08 (9.17)	22.0 (20.0)
≥ 600 and < 800	61	19.7	69	22.3	84	27.1	96	31.0	21.03 (9.43)	21.0 (20.0)
≥ 800	68	39.5	39	22.7	33	19.2	32	18.6	16.63 (9.58)	12.0 (18.0)
*p < 0.001 ^b										
Occupation										
Professionals	62	43.4	28	19.6	25	17.5	28	19.6	16.34 (9.66)	12.0 (15.0)
Services and Shopkeepers	33	19.5	48	28.4	45	26.6	43	25.4	20.17 (8.92)	18.0 (20.0)
Agriculture and Craft workers	41	25.8	35	22.0	41	25.8	42	26.4	19.62 (9.52)	18.0 (21.0)
Manual workers	46	16.9	52	19.1	83	30.5	91	33.5	22.13 (9.31)	24.0 (18.0)
*p < 0.001 ^b										

Table 1: Distribution of the study sample, according to the number of retained and missing teeth (standard deviation and interquartile range in parenthesis) by gender, brushing frequency, reason to go to the dentist, mouth dryness, personal income, and occupation.

^a: Based on independent samples T test

^b: Based on GLM analysis

	Mean	Median	Standard deviation	Pearson r with Missing Teeth (p)
Missing Teeth	20.03	19.00	9.545	-----
MMSE total raw score	24.83	25.00	2.047	-0.328 (< 0.001)
Age	74.84	75.00	6.055	0.428 (< 0.001)
Total years of education	7.03	6.00	3.893	-0.289 (< 0.001)

Table 2: Descriptive statistics (mean, median, standard deviation) of missing teeth, MMSE total raw score, age, and total years of education. Pearson correlation of these variables with missing teeth (p value of correlation in parenthesis).

Dependent variable	Independent variables	Categories	B	se(b)	Wald Chi-Square test	p	
Missing Teeth	Constant		0.657	6.9523	0.009	0.925	
	MMSE total raw score		-0.590	0.1890	9.732	0.002	
	Gender	Male		2.150	0.6684	10.344	0.001
		Female	Baseline				
	Reason to go to the dentist	Regular check up		-4.824	0.9094	28.134	< 0.001
		Occasionally		-0.906	0.7711	1.382	0.240
		When in trouble or pain	Baseline				
	Age (years)		0.492	0.0551	79.724	< 0.001	
	Total years of education		-0.427	0.0928	21.235	< 0.001	

Table 3: Generalized Linear Model for missing teeth by gender, reason to go to the dentist, age, MMSE total raw score, and total years of education.

The above results, are also confirmed by the GLM analysis. More specifically, the model indicated a significant gender effect (Wald test = 10.344, p < 0.001) with males losing 2.15 teeth on average more than females. Regarding the reason of dental attendance, people going to the dentist when in trouble or pain demonstrated approximately 4.8 on average more teeth loss than going regularly (Wald test = 28.134, p < 0.001). However, the difference with those going occasionally was not significant (Wald test=1.382, p = 0.240). Age contributed to tooth loss with 0.5 lost teeth approximately per year (Wald test = 79.724, p < 0.001). One unit increase in MMSE total raw score make us expect 0.6 approximately less teeth lost on average (Wald test = 9.732, p < 0.002). Finally, one year more in total education year's results in 0.4 approximately less teeth lost on average.

Discussion

This epidemiological study had an observational, cross-sectional design and sought to explain the relationship between tooth loss, cognitive ability and social indicators of older people living in the area of Greater Athens, Greece. To the best of our knowledge, this is the first study to explore and discover that tooth loss is associated to cognitive ability and socioeconomic inequalities in elders, visiting Day Centers in Greece.

The sample was based on an urban population, from two different Municipalities. Both municipalities had a wide variety of land value and population of different socioeconomic status according to education, occupation, and personal income. According to multivariate

analysis, the main finding from the study revealed a significant association between tooth loss and cognitive ability (MMSE score). Participant's age, income and years education were also significantly correlated with tooth loss. Those who brushed their teeth or dentures less than once a day and visited the dentist only when they had pain or a problem had significantly more missing teeth. There was also an occupation and income effect thus those being manual workers with lower income experienced significantly more missing teeth. Social inequalities in health are of great concern to public officials and epidemiologists in many countries, including prosperous societies, as differentials in morbidity and mortality among the socioeconomic groups remain a problem [9,49-52]. Unequal distribution of income and inequality in occupation and education contribute to differences in health outcomes and care, revealing the gap between the more affluent and privileged and less affluent [12,20,49-51].

The results of the present study are in accordance with two studies in Japan that also used the MMSE score. Their results showed tooth loss associated with MMSE score, and the higher the number of missing teeth the lower the MMSE score in Japanese elders [3,4]. Similarly, low MMSE scores were associated with increased risk of tooth loss and reported in a cohort study of community-dwelling men, members of the U.S. Department of Veterans Affairs, 28 - 70 years old. In older men MMSE scores were predicted by rates of tooth loss. Those results showed that the risk for low scores in MMSE test increased by 9% to 12% for each tooth lost in a decade [52]. The MMSE score has also been associated to tooth loss in Indonesian elders [53]. Another study that used the MMSE score but also a clinical diagnosis of dementia in Swedish elders showed that education and age levels largely explained associations of missing teeth and cognitive impairment [54]. The Health 2000 Health Examination Survey in Finland examined oral health and cognitive impairment in adults 55 years or older, and found statistical significant differences with more carious teeth and missing teeth or being edentulous without wearing a denture in those cognitively impaired [56]. Similarly, a study from China examined the association between tooth loss and cognitive function in elders 60 years or above found that the number of missing teeth was significantly associated with cognitive impairment [6]. Holst (2008) found in a 30-year-long study in Norwegian adults that the existence of oral health inequalities and the social gradient in edentulism impacted on the functional dentition of 20 or more natural teeth. She concluded that in a Norwegian population edentulism was a result of accumulated incidences of oral diseases and limited access to dental care either because of economic barriers or unavailability of dental care [1]. Analyses of the National Health and Nutrition Examination Survey (NHANES, 1999-2002), in the USA, examined dental care utilization, as a covariate and the link between cognitive function and tooth loss, and there was a strong association of dental care utilization and tooth loss [18] and the level of cognitive functioning with dental utilization [56]. In the present study we also found that lower scores of cognitive function have been associated with worse oral health status, and the impact of cognitive function on tooth loss merged when there were regular dental visits. However, in the present study we have both edentulous and dentate seniors 65 years and older, while in the studies of Wu, *et al.* [18,56] participants had at least one tooth and were 60 years and older.

A recent study by Manski, *et al.* [57] examined disparities in dental attendance among older adult populations in the USA, data from Health and Retirement Study (HRS), and in European countries, data from the Survey of Health, Ageing and Retirement in Europe (SHARE). It was found that income and education had stronger correlation with dental use, than dental insurance had. This result is partly in agreement with our study, in which education had a significant effect on tooth loss.

Furthermore, the present study's results partly agree with the results of a previous research in Greece by Mamai-Homata, *et al.* (2012), where education was the only significant predictor for tooth loss in adults [34].

The country's financial crisis is also a public health crisis and has impacted on people's daily life, and oral health inequalities and disparities have increased [58,59]. Increasing number of Greeks reported neglecting their health, and they avoided health or dental examinations either because could not afford to pay the cost or because of the distance to the clinics and travel expenses [59-61]. Unfortunately, a safety net for those frail or in great need does not exist. This emphasizes the need for strategies and upstream public policies interventions to eliminate disparities in oral health and social disparities within the country and inequalities in oral health across other countries, as this is one among others of global oral health objectives for the year 2020 [15,63].

Because older people have transition events affecting their lives (loss of a partner, widowed, retirement, and health problems), they are more vulnerable to financial crisis and may face hardship [64,65]. Furthermore, there is a need to implement national guidelines and a plan to promote equity in health and awareness of the importance of oral health on general health with emphasis on cognitive ability and the impact of social differences on health outcomes.

The limitations of the present study concerned its cross-sectional nature which does not establish a causal effect between tooth loss and cognitive ability. Also, generalization of the results to other populations should be done with caution, as the sample was not representative for the whole country. However, the strength of the study is the stratified and clustering methods used for the sample. Clustering methods were employed according to KAPI and postal codes. Moreover, this research was especially designed to explore factors affecting the oral health in elders aged 65 years and older, applying multivariate analysis to control confounding as much as possible.

Conclusion

Tooth loss was associated with cognitive ability (MMSE score) in elders, visiting Day Centers in Athens and Piraeus, Greece. In the examined population those with higher scores of MMSE score experienced less missing teeth. Also, those who were older, males, with less years of education, lower income, and felt dryness in the mouth had significantly more missing teeth. Participants who brushed their teeth or dentures less than once a day, visited the dentist only when they had trouble or pain and were manual workers with lower income experienced significantly more missing teeth. Future research is needed to further investigate the association between tooth loss and cognitive ability in older people, in Greece, in order to design and implement the appropriate dental public health measures for this high risk population group.

Competing Interests

The authors declare that they have no competing interests.

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Bibliography

1. Holst D. "Oral health equality during 30 years in Norway". *Community Dentistry and Oral Epidemiology* 36.4 (2008): 326-334.
2. Grabe HJ and Schwahn C. "Tooth loss and cognitive impairment". *Journal of Clinical Periodontology* 36.7 (2009): 550-557.
3. Okamoto N., et al. "Relationship of tooth loss to mild memory impairment and cognitive impairment: findings from the Fujiwara-Kyo study". *Behavioral and Brain Functions* 6 (2010): 77.
4. Saito Y and Sugawara N. "Cognitive function and number of teeth in a community-dwelling population in Japan". *Annals of General Psychiatry* 12.20 (2013): 1-6.
5. Peltzer K., et al. "Prevalence of loss of all teeth and associated factors in older adults in China, Ghana, India, Mexico, Russia and South Africa". *International Journal of Environmental Research in Public Health* 11.11 (2014): 11308-11324.
6. Luo J., et al. "Association between Tooth Loss and Cognitive Function among 3063 Chinese Older Adults: A Community-Based Study". *PLoS ONE* 10.3 (2015): e0120986.
7. Li J., et al. "Association between tooth loss and cognitive decline: A 13-year longitudinal study of Chinese older adults". *PLoS ONE* 12.2 (2017): e0171404.

8. Adler NE., *et al.* "Socioeconomic status and health the challenge of the gradient". *American Psychologist* 49.1 (1994): 15-24.
9. Marmot M. "Inequalities in health". *New England Journal of Medicine* 345.2 (2001): 134-136.
10. Sanders AE and Spencer AJ. "Evaluating the role of dental behavior in oral health inequalities". *Community Dentistry and Oral Epidemiology* 34.1 (2006): 370-377.
11. Bower E and Gulliford M. "Area deprivation and oral health in Scottish adults: a multilevel study". *Community Dentistry and Oral Epidemiology* 35.2 (2007): 118-129.
12. Morita I., *et al.* "Gradients in periodontal status in Japanese employed males". *Journal of Clinical Periodontology* 34.11 (2007): 952-956.
13. Tsakos G., *et al.* "Social gradients in oral health in older adults: Findings from the English longitudinal survey of aging". *American Journal of Public Health* 101.10 (2011): 1892-1899.
14. Moyses S. "Inequalities in oral health and oral health promotion". *Brazilian Oral Research* 26.1 (2012): 86-93.
15. Seerig LM., *et al.* "Tooth loss in adults and income: systematic review and meta-analysis". *Journal of Dentistry* 43.9 (2015): 1051-1059.
16. Sabbah W and Watt RG. "The role of cognitive ability in socio-economic inequalities in oral health". *Journal of Dental Research* 88.4 (2009): 351-355.
17. Noble JM., *et al.* "Periodontitis is associated with cognitive impairment among older adults: analysis of NHANES -III". *Journal of Neurology, Neurosurgery, and Psychiatry* 80.11 (2009): 1206-1211.
18. Wu B., *et al.* "Cognitive function and oral health among community-dwelling older adults". *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences* 63.5 (2008): 495-500.
19. Wu B., *et al.* "Cognitive function and dental care utilization among community -dwelling older adults". *American Journal of Public Health* 97.12 (2007): 2216-2221.
20. Stewart R., *et al.* "Oral Health and cognitive function in the Third National Health and Nutrition Examination Survey (NHANES)". *Psychosomatic Medicine* 70.8 (2008): 936-941.
21. Sabbah W., *et al.* "Social gradients in oral and general health". *Journal of Dental Research* 86.10 (2007): 992-996.
22. Tsakos G., *et al.* "Tooth loss associated with physical and cognitive decline in older adults". *Journal of American Geriatric Society* 63.1 (2015): 91-99.
23. Listl Stefan. "Oral health conditions and cognitive functioning in middle and later adulthood". *BMC Oral Health* 14 (2014): 70.
24. Huisman M., *et al.* "Socioeconomic inequalities in morbidity among the elderly a European overview". *Social Science and Medicine* 57.5 (2003): 861-873.
25. Macintyre S and Hunt K. "Socioeconomic position, gender and health: How do they interact?" *Journal of Health Psychology* 2.3 (1997): 315-334.
26. Von Dem KO., *et al.* "Socioeconomic status and health among the aged in the United States and Germany: a comparative cross sectional study". *Social Science and Medicine* 57.9 (2003): 1643-1652.
27. Chandola T., *et al.* "Social inequalities in self reported health in early old age: follow-up of prospective cohort study". *British Medical Journal* 334.7601 (2007): 990.

28. Ferraro KF and Farmer MM. "Utility of health data from social surveys. Is there a gold standard for measuring morbidity?" *American Sociological Review* 64.2 (1999): 303-315.
29. Hoffman R. "Do socioeconomic mortality differences increase with rising age?" *Demographic Research* 13.2 (2005): 35-62.
30. Ross CE and Wu CL. "Education, age, and the cumulative advantage in health". *Journal of Health and Social Behavior* 37.1 (1996): 104-120.
31. Becket M. "Converging health inequalities in later life. An artifact of mortality selection?" *Journal of Health and Social Behavior* 41.1 (2000): 106-119.
32. House JS, *et al.* "The social stratification of aging and health". *Journal of Health and Social Behavior* 35.3 (1994): 213-234.
33. Liang J, *et al.* "Old age mortality in Japan: Does the socioeconomic gradient interact with gender and age?" *Journal of Gerontology* 57B.5 (2002): S294-S307.
34. Mamai-Homata E, *et al.* "Tooth loss and rehabilitation in Greek middle-aged adults and senior citizens". *The International Journal of Prosthodontics* 25.2 (2012): 173-179.
35. Emke-Poulopoulou H. "Vieillesse Démographique et la vie des personnes âgées en Grèce". Greek-French Demography Conference EDHM INED (1990): 210-242.
36. Daniilidou VN, *et al.* "Health and social care in aging population: an integrated care institution for the elderly in Greece". *International Journal of Integrated Care* 3 (2003): e04.
37. Hellenic Statistical Authority. "Demographic and social characteristics of the Resident Population of Greece according to the 2011 Population" (2011).
38. Mouriki A, *et al.* "The political portrait of Greece". Athens: National Center for Social Research. EKKE (in Greek) (2015).
39. Commission of the European Communities. "Confronting demographic change: a new solidarity between the generations" (2005).
40. Hellenic Statistical Authority. "The population projections 2007 - 2050" (2017).
41. Forthofer R and Lee ES. "Biostatistics. A guide to design, analysis and discovery". 2nd edition. Academic Press (2006).
42. World Health Organization (WHO). "Oral health surveys. Basic methods. 4th edition" (2009).
43. Folstein MF, *et al.* "Mini-mental state. A practical method for grading the cognitive state of patients for the clinician". *Psychiatric Research* 12.3 (1975): 189-198.
44. Fountoulakis KN, *et al.* "Mini Mental State Examination (MMSE): A validation study in Greece". *American Journal of Alzheimer's Disease and other Dementias* 15 (2000): 342-345.
45. Solias A, *et al.* "Mini Mental State Examination: determination of cutoff scores according to age and educational level". *Psychiatriki* 25.4 (2014): 245-256.
46. Hellenic Statistical Authority. "Population at risk of poverty in Greece" (2017).
47. International Standard Classification of Education (ISCED-97) (1997).
48. International Standard Classification of Occupations (ISCO-08).

49. Mackenbach JP, *et al.* "Socioeconomic inequalities in morbidity and mortality in Western Europe". *Lancet* 349.9066 (1997): 1655-1659.
50. Knust AE. "Cross-national comparison of socioeconomic differences in mortality". [PhD Thesis]. Erasmus University Rotterdam (1996).
51. Bartley M. "Measuring socio-economic position". In: *Health inequality: an introduction to theories, concepts and methods*. Cambridge: Polity Press (2004): 222-225.
52. Kondo N. "Socioeconomic disparities and health: impacts and pathways". *Journal of Epidemiology* 22.1 (2012): 2-6.
53. Kaye EK, *et al.* "Tooth loss and periodontal disease predict poor cognitive function in older men". *Journal of American Geriatric Society* 58.4 (2010): 713-718.
54. Asia A, *et al.* "Association between tooth loss and the development of dementia on the Indonesian elders". *JSM Dentistry* 3.1 (2015): 1050.
55. Lexomboon D, *et al.* "Chewing ability and tooth loss: Association with cognitive impairment in an elderly population study". *Journal of American Geriatric Society* 60.10 (2012): 1951-1956.
56. Wu B, *et al.* "Cognitive function and dental care utilization among community-dwelling older adults". *American Journal of Public Health* 7.12 (2007): 497-500.
57. Manski R, *et al.* "Disparity in dental attendance among older adult populations: a comparative analysis across selected European countries and the United States". *International Dental Journal* 66.1 (2016): 36-48.
58. Damaskinos P and Economou C. "Systems for the provision of oral health care in the Black Sea countries part 10: Greece". *Oral Health Dental Management* 11.1 (2012): 3-10.
59. Damaskinos P, *et al.* "The healthcare system and provision of oral healthcare in European Union member states. Part 4: Greece". *British Dental Journal* 220.5 (2016): 253-260.
60. Simou E and Koutsogeorgou E. "Effects of the economic crisis on health and health care in Greece in the literature from 2009-2013: A systematic review". *Health Policy* 115.2-3 (2014): 111-119.
61. Eurobarometer. Special Eurobarometer 330. Oral Health (2010).
62. Syrjala AM, *et al.* "Relationship between cognitive impairment and oral health: results of the health 2000 Health Examination Survey in Finland". *Acta Odontologica Scandinavica* 65.2 (2007): 103-108.
63. Hobdell M, *et al.* "Global goals for oral health 2020". *International Dental Journal* 53 (2003): 285-288.
64. Petersen PE, *et al.* "Global oral health of older people-call for public health action". *Community Dental Health* 27.4 (2010): 257-267.
65. World Health Organization (WHO). "The Financial Crisis and Global Health Report of a High-Level Consultation". Geneva (2009).

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