Associations between Oral Health and Cancer in a National Representative Sample of Spanish Adults

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ABSTRACT

Background: The goal of this study was to investigate the association between several oral health outcomes and cancer in adults living in Spain.

Methods: Data from the Spanish National Health Survey 2017 were analysed. Seven oral health outcomes (dental caries, dental extraction, dental filling, gingival bleeding, tooth movement, dental material, and missing tooth) were assessed with questions with "yes" and "no" options. Cancer was assessed and defined with the following yes–no question: "Have you ever been diagnosed with malignant tumors?". The relationship of each oral health outcome and the number of poor oral health outcomes with cancer was studied in regression models adjusted for sex, age, marital status, education, smoking, and alcohol consumption.

Results: This study included 23,089 participants aged 15-103 years (45.9% of males; mean [standard deviation] age 53.4 [18.9] years). The prevalence of cancer was 5.0% in the overall population. After adjusting for several potential confounding factors, all oral health outcomes except missing tooth were significantly and positively associated with cancer (ORs ranging from 1.16 for dental filling to 1.48 for dental extraction). In addition, there was a positive and significant association between the number of poor oral health outcomes and cancer (OR=1.16, 95% CI=1.11-1.22).

Conclusions: On a nationally representative sample of 23,089 participants in Spain, poorer oral health outcomes were found in participants with history of cancer, with positive associations between several oral health outcomes as well as the number of poor oral health outcomes and cancer.

Keywords: Oral Health; Cancer; Spain; Epidemiology.

INTRODUCTION

Cancer is the second leading cause of death in Europe, with 259.5 per 100.000 inhabitants dying of cancer each year.[1] In Spain in 2018 there were 270.363 new cases reported,[2] with cancer also being the second most common cause of death.[3] Similarly, poor oral health causes a major health burden globally and oral diseases are estimated to affect around 3.5 billion people worldwide, with untreated dental caries being the most common health condition overall.[4]

Although a number of chronic illnesses and oral diseases share similar preventable risk factors (tobacco use, alcohol consumption, nutritional patterns high in free sugars), studies have also linked poor oral health as an independent risk factor for cardiovascular and cerebrovascular diseases and cancer. However, epidemiological studies investigating the associations between oral health and cancer have also shown poor oral health as an independent factor associated with cancer mortality.[5,6] The emerging evidence on the associations between poor oral health and general health outcomes was also noted by the World Health Organization, where the importance of good oral health in preventing fatal chronic illness was underlined as the part of the Global Oral Health Programme.[7]

Oral diseases such as periodontitis, gingivitis, tooth decay (dental caries) as well as tooth loss are considered to be clinical indicators of poor oral health. Tooth loss is often included in large epidemiological studies and used as an indicator of oral health, and is a robust indicator for oral health assessment given that teeth may be lost for a variety of reasons. Studies have shown that tooth loss above median is associated with an increase in relative risk of death from various cancers, especially upper gastrointestinal and oral cancers.[8] Periodontitis is an inflammatory condition leading to the gradual and irreversible destruction of the bone and connective tissue around the teeth, and has also been linked to increased risk of pancreatic cancer incidence [9] and pancreatic, lung and prostate cancer mortality, as well as overall cancer mortality.[5,6,10] While possible biological mechanisms linking carcinogenesis and oral health are still somewhat unclear, plausible mechanisms have been seen in studies that show the influence of inflammation as well as the influence of bacteria and viruses through changes in the immune response and signalling pathways between cells.[11] Here the influence of bacteria F. nucleatum and P. gingivalis seems to be most established in evidence as both these pathogens have been shown to influence molecular and biochemical changes which are associated with

carcinogenesis. Studies have also linked the persistence of human papillomavirus (HPV) infection and periodontal disease,[12] which also alone is characterised by release of inflammatory cytokines which are associated with carcinogenesis.[13]

Overall, due to differences in study design and study populations the evidence is not consistent across studies. A meta-analysis of studies from Chinese and US samples showed no associations between tooth loss or periodontitis for colorectal or pancreatic cancer, while others have shown that evidence for associations with lung cancer is considered strong.[14,15] Therefore it is necessary to conduct additional analyses in different geographical settings with different healthcare coverage schemes. Studies investigating associations between oral health outcomes and cancer in nationally representative samples have not yet been reported in Spain. The aim of our study was therefore to assess the overall prevalence of various oral health outcomes and their association with cancer prevalence.

METHODS

2.1. The Survey

Data from the Spanish National Health Survey 2017 were analysed. This survey was undertaken in Spain between October 2016 and October 2017. Details of the survey method have been previously published.[16,17] In brief, for the data collection, a stratified three-stage sampling was used in which the census sections were first considered, then the family dwellings, and then an adult (15 years or more) was selected within each dwelling. The sections were selected within each stratum with probability proportional to their size. The dwellings, in each section, were selected with equal probability by systematic sampling, prior arrangement by size of the dwelling. This procedure leads to self-weighting samples in each stratum. For the selection of the person who had to complete the Adult Questionnaire, the random Kish method was used, which assigns equal probability to all people aged 15+ years in the household. The sample was representative of the adult population residing in Spain and consisted of 23,089 people aged 15-103 years. The method of data collection used was computer-assisted personal interviewing (CAPI), conducted in the homes of the selected participants. Trained interviewers completed the questionnaires with the information provided by the participants. All participants signed an informed consent form before responding to the survey questions. This research was conducted in accordance with the Declaration of Helsinki of the World Medical Association.

2.2. Cancer (dependent variable)

Cancer was evaluated through the following yes–no question: "Have you ever been diagnosed with malignant tumors?" Those who answered affirmatively to the question were considered to have cancer.

2.3. Oral health outcomes (independent variables)

Oral health was evaluated through seven yes–no questions: 1. "Do you have dental caries?" (dental caries); 2. "Have you had dental extraction?" (dental extraction); 3. "Do you have dental filling?" (dental filling); 4. "Do you have gingival bleeding when you brush your teeth or spontaneously?" (gingival bleeding); 5. "Do you have tooth movement?" (tooth movement); 6. "Do you wear covers (crowns), bridges, other types of prostheses or dentures?" (dental material); and 7. "Do you have missing teeth that have not been replaced by prostheses?" (missing tooth). This questionnaire is a valid measure of self-reported dental health.[18] Oral health was analysed using these seven oral health outcomes separately and the number of poor oral health outcomes, a number ranging from 0 to 7.

2.4. Control variables

The selection of the control variables was based on previous studies showing that these factors are associated with both the dependent [19,20,21] and the independent variables [22,23,24,25] Sociodemographic variables included sex, age, marital status (married vs single/separated/divorced/widowed) and education (≤primary, secondary, ≥tertiary). Smoking status was self-reported and categorized as never, past and current smoking. Alcohol consumption in the last 12 months was self-reported and categorized as yes (any) and no (none).

2.5. Statistical analysis

The statistical analysis was performed with R 3.5.2 (The R Foundation).[26] Differences in the sample characteristics and in the prevalence of oral health outcomes (overall and by cancer status) were assessed using chi-squared tests for all variables except age (t-test). Effect size was calculated using phi coefficient, Cramer's V and Cohen's d for dichotomous variables, categorical variables with more than two categories and age, respectively. Associations between oral health outcomes (independent variables) and cancer (dependent variable) in the overall population were assessed using logistic regression models. Oral health outcomes were included in the regression models as categorical (each separate oral health outcome) and continuous variables (number of oral health outcomes). All models were adjusted for sex, age, marital status, education, smoking, and alcohol consumption. The control variables were included in the models as categorical variables with the exception of age which was included as a continuous variable. There were missing data for the following variables: marital status (n=39, 0.17%), smoking (n=22, 0.10%), alcohol consumption (n=26, 0.11%), dental caries (n=387,

1.68%), dental extraction (n=13, 0.06%), dental filling (n=30, 0.13%), gingival bleeding (n=26, 0.11%), tooth movement (n=26, 0.11%), dental material (n=18, 0.08%), and missing tooth (n=13, 0.06%). Complete-case analysis was carried out (only participants for which there was no missing data were included in the analyses, while participants with any missing data were excluded). Results from logistic regression analyses are presented as odds ratios (ORs) and 95% confidence intervals (CIs). The level of statistical significance was set at $p < 0.05$.

RESULTS

This study included 23,089 participants aged 15-103 years (45.9% of males; mean [standard deviation] age 53.4 [18.9] years). The prevalence of cancer was 5.0% in the overall population. Female sex, ≤primary education, past smoking, and no alcohol consumption were more frequent in individuals with cancer than in those without, while the cancer group was significantly older than the non-cancer group (**Table 1**). The prevalence of dental extraction (90.5% versus 77.0%), tooth movement (8.6% versus 5.2%), dental material (66.5% versus 44.0%), and missing tooth (64.3% versus 59.3%) were higher in cancer survivors than in those without any history of cancer, whereas dental filling was less common (60.5% versus 66.8%; **Table 2**).

The results of the multivariable regression analyses are displayed in **Figure 1**. After adjusting for several potential confounding factors (sex, age, marital status, education, smoking, and alcohol consumption), all oral health outcomes except missing tooth were significantly and positively associated with cancer (ORs ranging from 1.16 for dental filling to 1.48 for dental extraction). In addition, there was a positive and significant association between the number of poor oral health outcomes and cancer (OR=1.16, 95% CI=1.11-1.22).

DISCUSSION

Results of our analysis of associations of oral health outcomes and cancer in a nationally representative sample of Spanish adults showed high prevalence of dental extraction, dental fillings and missing teeth. The overall prevalence of cancer in this population was 5.0%. Cancer survivors also reported higher prevalence of numerous oral health problems (dental extraction, tooth movement, dental material, and missing tooth) and lower prevalence of dental filling. The adjusted regression analysis showed that all oral health outcomes except missing tooth increased the chances of reporting a cancer diagnosis by 16%-48%. Furthermore, a positive and

significant association between the number of poor oral health outcomes and cancer was observed (OR=1.16).

Periodontitis, which is the leading cause of gingival bleeding and tooth loss was found to be associated with various cancer outcomes. In a prospective cohort of over 28,800 participants in China,[27] it was reported that tooth loss was significantly associated with increased risk of oesophageal, gastric cardia and non-gastric cardia cancers, while in a US nationally representative sample of adults followed over 21 years showed that periodontitis at baseline was associated with increased risk of lung cancer mortality, after adjustment for various confounders.[5] Recently, in 2018 a Finnish register based study on over 68,000 adults during a 10 year follow-up showed that periodontitis was associated with increased risk of pancreatic cancer as well as lung and pancreatic cancer mortality,[6] while a 2019 study from the UK Biobank including a prospective cohort of 475,766 participant showed no associations between self-reported poor oral health outcomes and gastrointestinal cancer but did report an increased risk for hepatocellular carcinoma.[28] Even if a direct etiological link between periodontitis and cancer has not yet been established, both direct and indirect pathways have been proposed, given that chronic infections such as periodontitis are associated with carcinogenesis. Additionally, microorganisms found in the oral cavity may also play a role as some studies have confirmed that the presence of microorganisms is associated with carcinogenesis mediation in people with poor oral health outcomes.[13] These include both *Fusobacterium nucleatum and Porphyromonas gingivalis*,[15] both commonly found in the oral cavity that have also been found to promote development of cancer promoting environments and have been found in tissues of colorectal cancer patients.[29] Moreover, human papillomavirus has been found in biopsies of almost 25% of patients with periodontitis,[12] which may also explain the aetiology behind epidemiological evidence showing more HPV-positive oral cancers in patients with periodontitis.[30] Furthermore, studies have also reported presence of Helicobacter pylori as well as cytomegalovirus and Epstein-Barr virus in people with poor oral health outcomes.

Relationship between cancer prevalence and oral health outcomes may be bidirectional, given that a number of cancer patients have mental health comorbidities such as depression which may be associated with disinterest or lack of energy for oral hygiene.[31,32,33] Moreover, cancer therapy has also been found to be associated with oral mucositis, salivary gland function, xerostomia, issues with dental development, changes in taste and oral infections. All of which have been known to affect oral health and reduce oral health-related quality of life.[34,35,36,37,38] Additionally, poor oral health may limit functions such as speaking or eating, which may have

further negative consequences for mental, physical and social wellbeing in patients with cancer.[39]

Results of our analysis need to be viewed in the light of its limitations. The cross-sectional study design prohibits drawing of causal conclusions, therefore it is impossible to say if poor oral outcomes have influenced cancer incidence or if it is the other way around. Given that all variables have been self-reported, there is additional risk of bias. It was not possible to analyze which cancers are the most common in poor oral health because the question to assess cancer was "Have you ever been diagnosed with malignant tumors?". Also, as this study did not collect information on cancer therapy, it would be recommendable that future studies consider this aspect because of the potential side effects of cancer therapy on dental health.[40,41] However, the analysis provides so far unreported evidence of positive associations between oral health outcomes and cancer in a nationally representative sample of Spanish adults, contributing to the growing evidence of the influence of poor oral health on cancer.

CONCLUSION

Results of our study on a nationally representative sample of 23,089 participants in Spain showed poorer oral health outcomes in participants with history of cancer, and showed positive associations between several oral health outcomes as well as the number of poor oral health outcomes and cancer. Importance of good oral health in prevention of lethal chronic illness has been recognized by the WHOs Global Policy on Improvement of Oral Health in the 21st Century, where the need for more engagement from stakeholders in promotion and prevention programs has been voiced.[42] In Spain the national health system provides little coverage for oral health for adults, and more than 90% of dental professionals work in the private sector.[43] Furthermore, in cancer survivors more effort should be given for preventive dental care and education on proper dental hygiene. Health care professionals working with cancer survivors should actively screen patients for oral health outcomes.

KEYPOINTS

- 23,089 participants aged 15-103 years (45.9% of males; mean [standard deviation] age 53.4 [18.9] years).
- The prevalence of cancer was 5.0% in the overall population.

- After adjusting for several potential confounding factors, all oral health outcomes except missing tooth were significantly and positively associated with cancer (ORs ranging from 1.16 for dental filling to 1.48 for dental extraction).
- Positive and significant association between the number of poor oral health outcomes and cancer (OR=1.16, 95% CI=1.11-1.22).

REFERENCES

1. Eurostat. Causes of death — standardised death rate, 2016 (per 100 000 inhabitants) Online information available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Causes_of_death_%E2%80%94_standardised_death_rate,_2016_(per_100_000_inhabitants)_HLTH19.png (accessed 5 March 2021).
2. International Agency for Research on Cancer. Spain. 2018. Online information available at https://gco.iarc.fr/today/data/factsheets/populations/724-spain-fact-sheets.pdf (accessed 5 March 2021).
3. Eurostat. Causes of death — standardised death rate, EU-28, 2016 (per 100 000 inhabitants). Online information available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Causes_of_death_%E2%80%94_standardised_death_rate,_EU-28,_2016_(per_100_000_inhabitants)_HLTH19.png (accessed 5 March 2021).
4. World Health Organization. Oral health. 2020. Online information available at https://www.who.int/news-room/fact-sheets/detail/oral-health (accessed 5 March 2021).
5. Hujoel PP, Drangsholt M, Spiekerman C, Weiss NS. An exploration of the periodontitis–cancer association. *Ann Epidemiol* 2003; 13(5): 312-316.
6. Heikkilä P, But A, Sorsa T, Haukka J. Periodontitis and cancer mortality: Register-based cohort study of 68,273 adults in 10-year follow-up. *Int J Cancer* 2018; 142(11): 2244-2253.
7. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol* 2005; 33(2): 81-92.
8. Abnet CC, Qiao YL, Dawsey SM, Dong ZW, Taylor PR, Mark SD. Tooth loss is associated with increased risk of total death and death from upper gastrointestinal cancer, heart disease, and stroke in a Chinese population-based cohort. *Int. J. Epidemiol.* 2005; 34(2): 467-474.
9. Michaud DS, Joshipura K, Giovannucci E, Fuchs CS. A prospective study of periodontal disease and pancreatic cancer in US male health professionals. *J Natl Cancer Inst* 2007; 99(2): 171-175.

10. Chung PC, Chan TC. Association between periodontitis and all-cause and cancer mortality: retrospective elderly community cohort study. *BMC Oral Health* 2020; 20(1): 1-11.
11. Gagnaire A, Nadel B, Raoult D, Neefjes J, Gorvel JP. Collateral damage: insights into bacterial mechanisms that predispose host cells to cancer. *Nat Rev Microbiol.* 2017; 15(2): 109-128.
12. Hormia M, Willberg J, Ruokonen H, Syrjänen S. Marginal periodontium as a potential reservoir of human papillomavirus in oral mucosa. *J Periodontol* 2005; 76(3): 358-363.
13. Tezal M, Sullivan MA, Reid ME, et al. Chronic periodontitis and the risk of tongue cancer. *Arch. Otolaryngol. Head Neck Surg.* 2007; 133(5): 450-454.
14. Ren HG, Luu HN, Cai H, et al. Oral health and risk of colorectal cancer: results from three cohort studies and a meta-analysis. *Ann. Oncol.* 2016; 27(7): 1329-1336.
15. Chung M, York BR, Michaud DS. Oral Health and Cancer. *Curr. Oral Health Rep.* 2019; 6(2): 130-137.
16. Ministerio de Sanidad, Consumo y Bienestar Social & Instituto Nacional de Estadística. Spanish National Health Survey 2017: Methodology. Online information available at https://www.mscbs.gob.es/estadEstudios/estadisticas/encuestaNacional/encuestaNac2017/ENSE17_Metodologia.pdf (accessed 5 March 2021).
17. Ministerio de Sanidad, Consumo y Bienestar Social & Instituto Nacional de Estadística. Spanish National Health Survey 2017: Questionnaire of adults. Available at https://www.mscbs.gob.es/estadEstudios/estadisticas/encuestaNacional/encuestaNac2017/ENSE17_ADULTO_.pdf (accessed 5 March 2021).
18. Barriuso Lapresa L, Sanz-Barbero B. Variables asociadas al uso de los servicios de salud bucodental por la población preescolar en España: un análisis de la Encuesta Nacional de Salud. *Rev Esp Salud Publica* 2012; 86: 115-124.
19. Neal RD, Allgar VL. Sociodemographic factors and delays in the diagnosis of six cancers: analysis of data from the 'National Survey of NHS Patients: Cancer'. *Br. J. Cancer* 2005; 92(11): 1971-1975.
20. Albano JD, Ward E, Jemal A, et al. Cancer mortality in the United States by education level and race. *J Natl Cancer Inst* 2007; *99*(18): 1384-1394.
21. Mashberg A, Boffetta P, Winkelman R, Garfinkel L. Tobacco smoking, alcohol drinking, and cancer of the oral cavity and oropharynx among US veterans. *Cancer* 1993; *72*(4): 1369-1375.

22. Vargas CM, Macek MD, Marcus SE. Sociodemographic correlates of tooth pain among adults: United States, 1989. *Pain* 2000; 85(1-2): 87-92.
23. Jiang Y, Okoro CA, Oh J, Fuller DL. Peer reviewed: sociodemographic and health-related risk factors associated with tooth loss among adults in Rhode Island. *Prev Chronic Dis* 2013; 10: 1-12.
24. Murakami K, Ohkubo T, Hashimoto H. Socioeconomic inequalities in Oral health among unmarried and married women: evidence from a population-based study in Japan. *J. Epidemiol.* 2018; 28(8): 341-346.
25. Tanner T, Päkkilä J, Karjalainen K, et al. Smoking, alcohol use, socioeconomic background and oral health among young Finnish adults. *Community Dent Oral Epidemiol.* 2015; 43(5): 406-414.
26. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. 2018. Online information available at https://www.R-project.org/ (accessed 5 March 2021).
27. Abnet CC, Qiao YL, Mark SD, Dong ZW, Taylor PR, Dawsey SM. Prospective study of tooth loss and incident esophageal and gastric cancers in China. *Cancer Causes Control* 2001; 12(9): 847-854.
28. Jordão HW, McKenna G, McMenamin UC, Kunzmann AT, Murray LJ, Coleman HG. The association between self-reported poor oral health and gastrointestinal cancer risk in the UK Biobank: A large prospective cohort study. *United European Gastroenterol J* 2019; 7(9): 1241-1249.
29. Bullman S, Pedamallu CS, Sicinska E, et al. Analysis of Fusobacterium persistence and antibiotic response in colorectal cancer. *Science* 2017; 358(6369): 1443-1448.
30. Tezal M, Nasca MS, Stoler DL, et al. Chronic periodontitis− human papillomavirus synergy in base of tongue cancers. *Arch. Otolaryngol. Head Neck Surg.* 2009; 135(4): 391-396.
31. Ahmed KE. The psychology of tooth wear. *Spec Care Dentist* 2013; 33(1): 28-34.
32. Little JW. Dental implications of mood disorders. *Gen. Dent.* 2004; 52(5): 442-450.
33. McFarland ML, Inglehart MR. Depression, self-efficacy, and oral health: An exploration. *Oral Health Dent Manag.* 2010; 9(4): 214-222.
34. Jellema AP, Slotman BJ, Doornaert P, Leemans CR, Langendijk JA. Impact of radiation-induced xerostomia on quality of life after primary radiotherapy among patients with head and neck cancer. *Int. J. Radiat. Oncol. Biol. Phys.* 2007; 69(3): 751-760.

35. Keefe DM, Schubert MM, Elting LS, et al. Updated clinical practice guidelines for the prevention and treatment of mucositis. *Cancer* 2007; 109(5): 820-831.
36. Pow EHN, McMillan AS, Leung WK, Kwong DLW, Wong MCM. Oral health condition in southern Chinese after radiotherapy for nasopharyngeal carcinoma: extent and nature of the problem. *Oral Dis* 2003; 9(4): 196-202.
37. Shiboski CH, Hodgson TA, Ship JA, Schiødt M. Management of salivary hypofunction during and after radiotherapy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; 103: S66.e1-19.
38. PDQ Supportive and Palliative Care Editorial Board. Oral Complications of Chemotherapy and Head/Neck Radiation (PDQ®): Health Professional Version. In: *PDQ Cancer Information Summaries*. Bethesda (MD): National Cancer Institute (US); 2002.
39. Kisely S. No mental health without oral health. *Can J Psychiatry* 2016; 61(5): 277-282.
40. Wong HM. Oral complications and management strategies for patients undergoing cancer therapy. *Scientific World Journal* 2014; 581795: 1-14.
41. Epstein JB, Thariat J, Bensadoun RJ, et al. Oral complications of cancer and cancer therapy: from cancer treatment to survivorship. *CA Cancer J Clin*. 2012; 62(6): 400-422.
42. Petersen PE. Global policy for improvement of oral health in the 21st century–implications to oral health research of World Health Assembly 2007, World Health Organization. *Community Dent Oral Epidemiol* 2009; 37(1): 1-8.
43. Bravo M, San Martín L, Casals E, Eaton KA, Widström E. The healthcare system and the provision of oral healthcare in European Union member states. Part 2: Spain. *Br Dent J* 2015; 219(11): 547-551.

Tables and Figures

Table 1. Sample characteristics (overall and by cancer status)

Characteristics	Category	Overall (N=23,089)	Cancer		Effect size[a]	P-value[b]
			No (N=21,943)	Yes (N=1,146)		
Sex	Male	45.9	46.3	38.7	0.03	<0.001
	Female	54.1	53.7	61.3		
Age	Mean (SD)	53.4 (18.9)	52.7 (18.9)	67.1 (13.4)	0.77	<0.001
Marital status	Single/separated/divorced/widowed	45.9	46.0	43.5	0.01	0.102
	Married	54.1	54.0	56.5		
Education	≤Primary	31.2	30.2	50.0	0.09	<0.001
	Secondary	43.0	43.7	31.0		
	≥Tertiary	25.8	26.1	19.0		
Smoking	Never	50.8	50.8	50.3	0.05	<0.001
	Past	25.8	25.4	34.4		
	Current	23.4	23.8	15.3		
Alcohol consumption	No	35.8	35.2	47.4	0.05	<0.001
	Yes	64.2	64.8	52.6		

Abbreviation: SD standard deviation.

Cancer was assessed with a question with "yes" and "no" options.

Values are percentages unless otherwise stated.

[a] Effect size was calculated using phi coefficient, Cramer's V and Cohen's d for dichotomous variables, categorical variables with more than two categories and age, respectively.

[b] P-values were based on chi-squared tests except for age (t-test).

Table 2. Prevalence of different oral health outcomes in the overall population and by cancer status

Oral health outcome	Overall (N=23,089)	Cancer		Effect size[a]	P-value[b]
		No (N=21,943)	Yes (N=1,146)		
Dental caries	20.6	20.6	20.8	0.00	0.907
Dental extraction	77.7	77.0	90.5	0.07	<0.001
Dental filling	66.5	66.8	60.5	0.03	<0.001
Gingival bleeding	14.6	14.6	14.8	0.00	0.882
Tooth movement	5.4	5.2	8.6	0.03	<0.001
Dental material	45.1	44.0	66.5	0.10	<0.001
Missing tooth	59.5	59.3	64.3	0.02	<0.001

Cancer and oral health outcomes were assessed with questions with "yes" and "no" options. Oral health outcomes included dental caries, dental extraction, dental filling, gingival bleeding, tooth movement, dental material, and missing tooth.

Values are percentages unless otherwise stated.

[a] Effect size was calculated using phi coefficient.

[b] P-values were based on chi-squared tests.

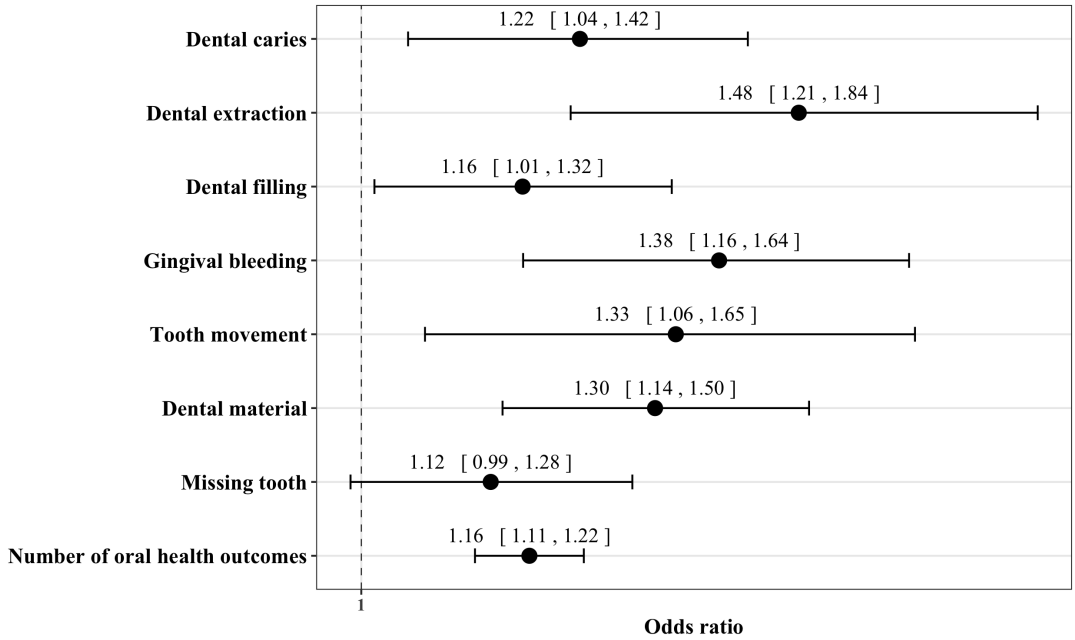

Figure 1. Association between oral health outcomes (independent variables) and cancer (dependent variable) in the overall population

Seven oral health outcomes and cancer were assessed with questions with “yes” and “no” options. Oral health outcomes included dental caries, dental extraction, dental filling, gingival bleeding, tooth movement, dental material, and missing tooth. Oral health outcomes were included in the regression models as categorical (each separate oral health outcome) and continuous variables (number of oral health outcomes).
Logistic regression models were adjusted for sex, age, marital status, education, smoking, and alcohol consumption.